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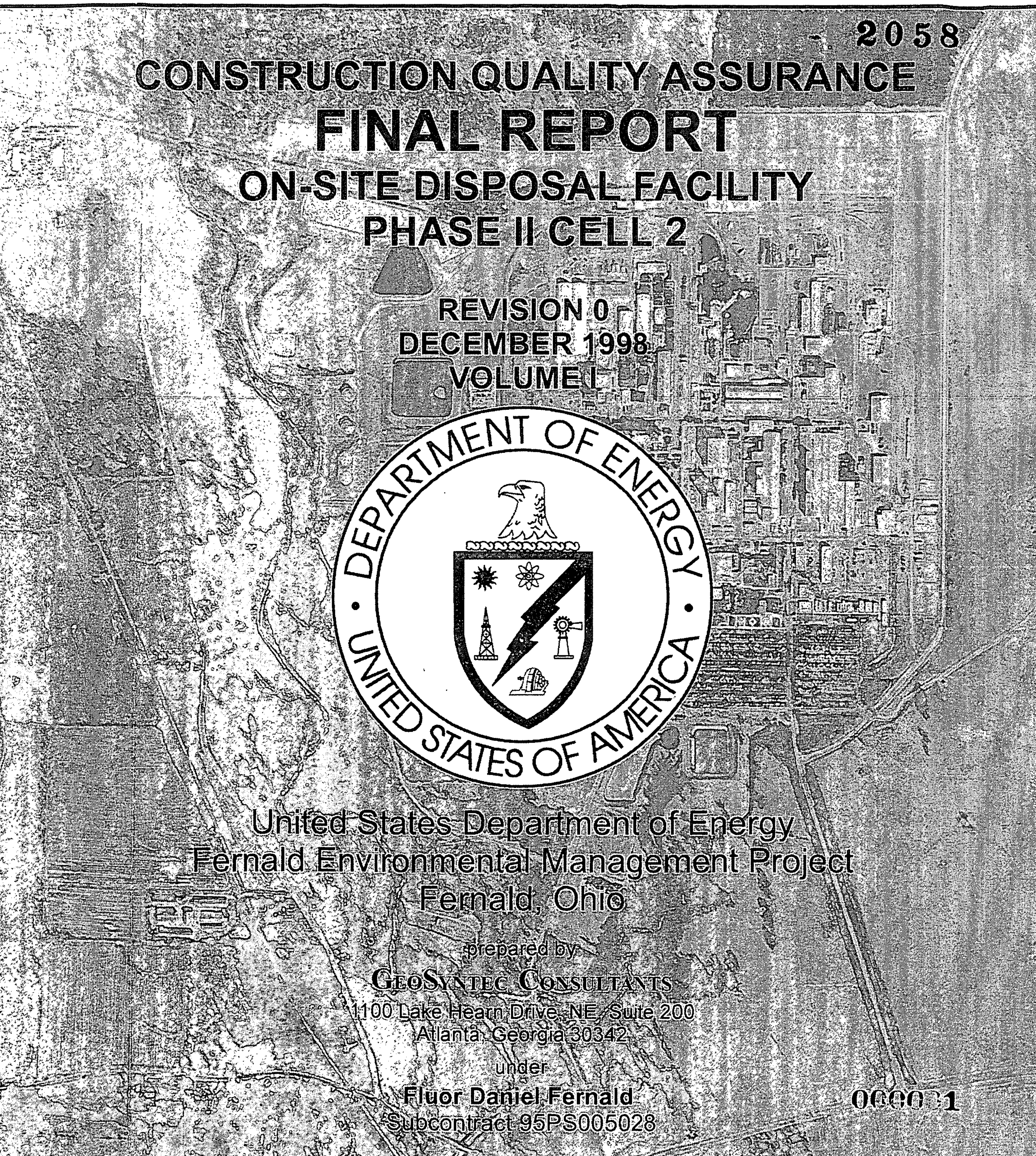

2058

# CONSTRUCTION QUALITY ASSURANCE
# FINAL REPORT
## ON-SITE DISPOSAL FACILITY
## PHASE II CELL 2

**REVISION 0**
**DECEMBER 1998**
**VOLUME I**

United States Department of Energy
Fernald Environmental Management Project
Fernald, Ohio

prepared by

GEOSYNTEC CONSULTANTS
1100 Lake Hearn Drive, NE, Suite 200
Atlanta, Georgia 30342

under

**Fluor Daniel Fernald**
Subcontract 95PS005028

000001

NO. 2

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# CONSTRUCTION QUALITY ASSURANCE FINAL REPORT

# ON-SITE DISPOSAL FACILITY PHASE II CELL 2

**December 1998**
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## United States Department of Energy

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# 1 INTRODUCTION

## 1.1 Background

The On-site Disposal Facility (OSDF) is a mixed radioactive low-level waste disposal facility dedicated to the Fernald Environmental Management Project (FEMP) that will, upon completion, cover approximately 90 acres (36 hectares). The OSDF is owned by DOE and is being constructed, filled, and operated by Fluor Daniel Fernald (FDF) as part of FEMP remediation activities.

DOE intends to build only one OSDF. Therefore, the OSDF is designed to accommodate all or any portion of the total volume of impacted material meeting the WAC that results from remediation of the operable units. The total volume of material from all operable units is estimated to be 2.5 million bank/unbulked (i.e., in-place prior to excavation) cubic yards (1.9 million bank/unbulked cubic meters). The OSDF will be constructed over a period of time to be determined, depending on availability of funding.

The first year of construction (1997) included the OSDF Phase I and Leachate Conveyance System projects. A Construction Quality Assurance Final Report for OSDF Phase I liner system including its protective layer and the Leachate Conveyance System was issued in January 1998 for the first year construction.

Cell 2 was constructed as part of OSDF Phase II in 1998. The OSDF Cell 2 construction consists of a double composite liner system of the same design as Cell 1 of the OSDF. Ancillary construction included drainage structure construction for storm water runoff, additional borrow area development, excavation in the area of future Cell 3 construction, and grading and temporary seeding of areas external to Cell 2.

## 1.2 Report Overview

This CQA Certification report summarizes the Construction Quality Control (CQC) and Construction Quality Assurance (CQA) activities performed by GeoSyntec Consultants (GeoSyntec) during the construction of the Cell 2 project at the FEMP. CQC and CQA activities performed by GeoSyntec will be collectively referred to as CQA activities in this report. The CQA activities performed by GeoSyntec included monitoring of (i) soils construction; (ii) geosynthetics installation; (iii) protective layer placement; and (iv) leachate conveyance system repair and construction. The CQA activities were performed to confirm that the construction materials and procedures that were monitored were in compliance with the certified-for-construction drawings, technical specifications, CQA Plan and other related support plans and approved changes.

Also included in this Cell 2 report are results of monitoring of Phase 1 Cell 1 and Leachate Conveyance System construction items that were not completed in 1997. The interface between Phase I of the OSDF and the Leachate Conveyance System was at the stub-out of the manholes for Cells 2 and 3. These items represent a very small portion of the 1998 work.

This report was prepared for Fluor Daniel Fernald (FDF) by Mr. Collin Sukow and Mr. Daniel G. Bodine, P.E., both of GeoSyntec. In accordance with GeoSyntec's peer review policy the report was reviewed by Mr. David Phillips, P.E. of GeoSyntec.

## 1.3 Report Organization

This final report is organized as described below.

- A description of the project is provided in Section 2.
- A description of the CQA program, including a summary description of specific tasks performed under the program, and a listing of project personnel, are presented in Section 3.
- A description of the CQA monitoring and testing activities performed during the earthwork portion of the project, including the protective layer, is provided in Section 4.
- A description of the CQA monitoring and testing activities performed during the geosynthetics installation is provided in Section 5.
- A description of the CQA monitoring and testing activities performed during Phase I construction completion and leachate conveyance system repair is provided in Section 6.

- A summary of the observations resulting from the CQA monitoring and testing activities performed by GeoSyntec; and a certification statement verifying that OSDF Cell 2 was constructed in accordance with the Technical Specifications and Construction Drawings are presented in Section 7.

Documentation and record drawings presenting the results of the CQA monitoring and testing activities performed by GeoSyntec are contained in the appendices to this report. Weekly reports prepared by the CQA Site Manager and Resident Engineer are also included in the appendices. Daily reports prepared by the CQA monitors are not included in appendices; however, these daily reports can be made available on request.

## 2 PROJECT DESCRIPTION

The OSDF design incorporates a double-composite liner system and other engineering controls that meet the applicable or relevant and appropriate requirements (ARARs), DOE functional requirements, and general design criteria as described in the Design Criteria Package (DCP) developed and approved for the project during the design phase. The double-composite liner system forming the base of the OSDF Cell 2 consists of the following components, from top to bottom:

- 7 oz/ $yd^2$ (240 $g/m^2$) needle punched nonwoven geotextile filter;
- 1.0-ft (0.3-m) thick granular leachate collection system (LCS) drainage layer;
- 10 $oz/yd^2$ (340 $g/m^2$) needle punched nonwoven geotextile cushion;
- 80-mil (2.0 mm) thick high density polyethylene (HDPE) geomembrane (textured) component of a composite primary liner, hereafter referred to as geomembrane primary liner;
- a geosynthetic clay liner (GCL);
- 1.0-ft (0.3-m) thick granular leak detection system (LDS) drainage layer;
- 10 $oz/yd^2$ (340 $g/m^2$) needle punched nonwoven geotextile cushion;
- 80-mil (2.0 mm) thick HDPE geomembrane (textured) component of a composite secondary liner, hereafter referred to as geomembrane secondary liner;
- a geosynthetic clay liner (GCL);
- 36 in. (.9-m) thick low-permeability compacted clay liner; and
- subgrade or compacted fill hereafter referred to as subgrade.

The Cell 2 foot print has a rectangular configuration approximately 400 ft (122 m) long and 700 ft (213-m) wide. Cell 2 construction also includes a temporary end to the liner system in the Cell 3 footprint.

The leachate conveyance system was completed in 1997 and is operational. It is composed of manholes for cells 1, 2 and 3, HDPE gravity piping, a permanent lift station, and a HDPE force main designed and constructed to convey leachate to the Advanced Waste Water Treatment Facility. The only portion of the leachate conveyance system covered by this report is completion and repair work at the permanent manhole cover slab for Cells 2 and 3 and a HDPE pipe installation from the Cell 2 and Cell 3 manholes to their respective cells.

The Certified-For-Construction Drawings and Technical Specifications (dated October 1996) for the OSDF and leachate conveyance system were prepared by GeoSyntec and approved by USEPA and OEPA. The prime contractor for completion-construction of the Leachate Conveyance System Cell 2 and Cell 3 manholes and piping was Village Building Services, Inc. (VBS), with assistance from FDF. The contractor for construction of OSDF Phase I and Phase II projects was Petro Environmental Technologies, Inc. (PETRO). Installation of the geosynthetic components of the double-liner system for Cell 2 was performed by Solmax Geosynthetics Incorporated (Solmax), as subcontractor to PETRO. The surveyor retained by PETRO for the OSDF Phase II projects was Hirsch and Associates. As required by the project specifications, Hirsch and Associates surveyed the required layers of the liner system (i.e., subgrade, top of compacted clay, layout of secondary and primary geomembrane liners, top of drainage layers, the invert of primary and secondary collection pipes, and the top of the protective layer) and provided the subgrade and layer record drawings. GeoSyntec prepared the record geomembrane panel drawings. CQA monitoring, testing, and documentation was provided by GeoSyntec. A list of primary personnel involved in the OSDF Phase II project is included in Section 3.2 of this report.

Construction activities monitored by GeoSyntec's CQA personnel for the OSDF Phase II Cell 2 project are discussed in Section 3.

The approval process for construction materials used during the Cell 2 project required submittal of manufacturer's data, quality control certifications, and shop drawings to the Construction Manager for review and approval. On the Phase II project

FDF was responsible for procurement of the geosynthetics. The Construction Manager, FDF QA, FDF Engineering and the Resident Engineer reviewed, commented (as needed), and approved construction materials for use during construction. The submittal details and approvals are summarized in the Resident Engineer's weekly reports presented in Appendix C.

Earthwork construction associated with the completion of the Leachate Conveyance System Cell 2 and Cell 3 piping began on 7 April 1998 and was completed on 29 May 1998. Earthwork associated with OSDF Phase I completion construction and change order work began on 11 April 1998. Phase II construction began in June 1998. Solmax began and completed installation of the secondary geomembrane liner on 11 September 1998 and 14 October 1998, respectively. Solmax began and completed installation of the primary geomembrane liner on 14 October 1998 and 3 November 1998, respectively. The construction of the OSDF Cell 2 liner system was completed on 11 November 1998, prior to beginning placement of the liner system's protective layer. Protective layer placement began on 11 November 1998 and was completed on 20 November 1998.

# 3 CONSTRUCTION QUALITY ASSURANCE PROGRAM

## 3.1 Scope of Services

### 3.1.1 Overview

The scope of CQA services performed by GeoSyntec during the OSDF Phase II Cell 2 project included:

- review of documents;
- monitoring, testing, and documentation of field operations; and
- preparation of the final report and record drawings.

These services are described in the following subsections of this report.

### 3.1.2 Review of Documents

As previously noted, this final report summarizes the CQA activities performed by GeoSyntec during the 1998 construction season. The CQA activities conducted by GeoSyntec were intended to satisfy the requirements of the following documents:

- "Technical Specification, OSDF Phase I," Revision 0, October 1996;
- "Technical Specification, OSDF Phase II," Revision 0, November 1997;
- "Technical Specifications, Leachate Conveyance System, OSDF," Revision 0, October 1996;
- "Construction Quality Assurance Plan, OSDF," Revision 0, May 1997;
- "OSDF Phase I," Construction Drawings, Latest Revisions;
- "OSDF Phase II," Construction Drawings, Latest Revisions;

- "Leachate Conveyance System," Construction Drawings, Revision 0, August 1996; and

- "Impacted Material Placement Plan," Revision 0, January 1998.

During construction, design change notices (DCNs) were prepared which modified these documents. Documents containing the details of these DCNs are referenced in the appropriate sections of this report, and are included in Appendix T. Also included in Appendices S and U are requests for clarification of information (RCIs) and nonconformance reports (NCRs). Only those documents relating to the completion of Phase I and Leachate Conveyance System (LCS) work items and construction of Phase II Cell 2 are provided in the above appendices. Phase I and LCS documents related to the 1997 work were included in the Final Construction Quality Assurance Report for Phase I and LCS.

The above documents (including the DCNs and RCIs) will be collectively referred to as the project documents in this final report. Prior to the commencement of on-site CQA activities, GeoSyntec Field Services personnel for familiarity reviewed the project documents.

### 3.1.3 CQA Field Operations

The following activities were performed as part of GeoSyntec's on-site CQA services:

Earthwork:

- collecting conformance test samples of soils considered for use as compacted fill, compacted clay liner, and granular components of the leachate conveyance system and/or Cell 2 liner system for testing in either the on-site or off-site geotechnical laboratories;

- performing geotechnical conformance testing in field soils laboratory;

- reviewing and evaluating geotechnical laboratory conformance test results to ensure compliance with the requirements of the project documents;

- monitoring proofrolling and subgrade preparation;
- monitoring trenching operations for installation of the leachate conveyance piping;
- monitoring placement and compaction of pipe and manhole embedment fill and backfill;
- monitoring of grading operations (i.e., cutting and filling) on the cell floor;
- monitoring final preparation of the cell floor subgrade;
- monitoring perimeter berm construction;
- testing of the in-place moisture/density of the compacted fill and compacted clay liner;
- monitoring placement of the leachate collection and leak detection systems;
- verifying (by means of reviewing the surveyor's data, and/or observing the surveyor's survey stakes) that the elevations and the thicknesses of the soil layers are consistent with the project documents;
- monitoring placement of backfill in the perimeter anchor trench; and
- monitoring placement of compacted clay layers for the clay wedge above anchor trench.

Geosynthetics:

- tracking the inventory of geosynthetic materials (i.e., HDPE pipes, liner penetration boxes, GCL, geomembrane, and geotextile rolls) delivered to site;
- monitoring geosynthetic materials delivered to site to observe whether the materials had been damaged during transportation or handling, and if so, notifying FDF and marking damage for replacement or repair;

- collecting and reviewing geosynthetic manufacturers' certification documents to verify compliance with the requirements of the project documents;
- collecting geosynthetic conformance samples and forwarding samples to the off-site geosynthetics testing laboratory;
- reviewing and evaluating geosynthetic laboratory conformance test results to verify compliance with the requirements of the project documents;
- monitoring trial welds and production welding of HDPE pipes;
- monitoring seaming configuration;
- monitoring deployment and installation of geosynthetic materials and marking damage for replacement or repair;
- monitoring overlapping of adjacent GCL panels during installation;
- monitoring placement of bentonite between overlapping GCL panels;
- monitoring geomembrane trial seaming operations and field testing;
- monitoring geomembrane production seaming operations;
- monitoring nondestructive testing using calibrated equipment of the geomembrane seams;
- selecting geomembrane destructive seam sample locations, monitoring sample collection and field testing using a calibrated tensiometer, distributing destructive samples to the geosynthetics laboratory, and reviewing laboratory test results to verify compliance with the requirements of the project documents;
- monitoring the joining of adjacent geotextile panels;
- monitoring repairs to portions of the geosynthetics that were observed to have defects, or that failed destructive or nondestructive testing; and

- monitoring the placement of the geosynthetics and the backfilling and compacting of compacted clay material in the anchor trench.

Leachate Collection and Leak Detection Systems (LCS and LDS):

- monitoring installation and field air pressure testing of liner penetration boxes;
- monitoring installation of leachate sideslope penetrations;
- testing of the in-place moisture/density of compacted pipe embedment material, and compacted fill for the conveyance pipe;
- reviewing source qualification test results on samples of aggregate used in the LCS and LDS layer systems;
- monitoring deployment of the geotextile cushions;
- monitoring placement of the LCS and LDS layer aggregates;
- monitoring of horizontal well installation;
- monitoring placement of the LCS and LDS layer aggregate monitoring installation of the LCS collection pipe, LCS redundant pipe, LDS collection pipe, and LCS and LDS drainage corridor aggregate;
- monitoring repair work of manhole piping to Cells 2 and 3;
- monitoring of the repair placement of concrete, the quality control sampling of concrete specimens, and shipment of concrete specimens to an off-site laboratory for testing; and
- visual monitoring of hydrostatic and pneumatic pressure testing of the LCS, LDS and horizontal well piping for Cell 2 and Cell 3;

Impacted Material Placement

- monitoring of Cell 2 temporary access ramp installation;

- monitoring of Cell 2 protective layer placement.

During construction activities involving monitoring and/or testing, the observations made and test results obtained by GeoSyntec CQA personnel were compared to the project documents. FDF and/or the appropriate contractor were notified of deficiencies in construction practices and/or materials so the contractor could take the appropriate corrective actions. The corrective actions were monitored and/or tested by CQA personnel to ensure compliance with the project documents.

Upon substantial completion of construction and testing of the OSDF Phase II Cell 2 project, an interim construction certification letter was prepared and submitted to FDF. A copy of the letter is included in Appendix B. This final certification report includes all construction required by the project documents except those items listed below. These items will be completed as weather permits or as directed by FDF. Monitoring and testing documentation for these items will be included in either an addendum to this report or in the certification report for OSDF Cell 3 construction. Items not complete at the time of this report include:

- final Cell 2 access ramp;
- miscellaneous punch-list items maintained by FDF; and
- seeding of completed Cell 2 slopes.

### 3.1.4 Final Report and Record Drawings

Record drawings and this CQA certification report were prepared as the final task of the CQA program for the 1998 construction season. This report summarizes the CQA monitoring, testing, and documentation activities performed by GeoSyntec.

During construction, CQA personnel maintained documentation of on-site CQA activities. Daily documentation consisted of daily field reports and testing and monitoring logs. These documents were used to prepare weekly field summaries. CQA personnel also documented the results of on-site geotechnical laboratory testing and reviewed results of off-site geotechnical laboratory testing conducted as part of the CQA program. In addition, manufacturer quality control (QC) certificates and quality control test results for the geosynthetic materials were provided to GeoSyntec for review; these documents are included in Appendix H of this final report. Surveyor's data were provided to GeoSyntec for review. The contractor's licensed surveyor prepared tops of layer record drawings. GeoSyntec prepared Geomembrane panel placement drawings. The recording drawings are included in Appendix R of this final report. Geosynthetics CQA conformance test results are also presented in Appendix I to this final report. Descriptions of the construction activities and the CQA documentation are presented in the narrative sections of this report.

Volume I of this CQA report contains the narrative sections of the report and Appendices A and B. Volume II of this report contains Appendices C through F; Volume III contains Appendices F (continued) through G; Volume IV contains Appendix H; Volume V contains Appendices I through P; Volume VI contains Appendices Q through R; and Volume VII contains Appendices S through U. A summary of the documentation included in the appendices to the Cell 2 certification report is provided below:

- Appendix A: Photographic Documentation
- Appendix B: Cell 2 Interim Construction Certification Letter
- Appendix C: Weekly Field Reports
- Appendix D: Minutes of OSDF Weekly Construction Meetings
- Appendix E: Personnel Logs
- Appendix F: Cell 2- Geotechnical Laboratory Test Results
  Field Laboratory Test Results
    Compacted Fill
    Compacted Clay Liner
    Pipe Embedment Fill
    Granular Drainage Material
    Granular Filter Material
  Off-Site Laboratory Test Results
    Granular Drainage Material

Compacted Clay

- Appendix G: Cell 2 - Field Moisture/Density Test Results
  Compacted Fill
  Compacted Clay Liner

- Appendix H: Cell 2 Manufacturer's Quality Control Documentation
  FDF/Manufacturers Submittals
  Contractors/Installers Submittals

- Appendix I: Cell 2 Geosynthetic Conformance Test Results
  Geosynthetic Clay Liner
    Hydraulic Conductivity Test Results
    Direct Shear Test Results
    Direct Shear Compliance Packages
  Geomembrane
  Geotextile

- Appendix J: Cell 2 Contractor's Certificate of Acceptance of Subgrade

- Appendix K: Cell 2 Geomembrane Panel Placement Monitoring Logs
  Secondary
  Primary

- Appendix L: Cell 2 Geomembrane Trial Seam Logs;
  Fusion
  Extrusion

- Appendix M: Cell 2 Geomembrane Production Seam Logs;
  Secondary
  Primary

- Appendix N: Cell 2 Geomembrane Destructive Seam Test Logs and

Laboratory Test Results
Secondary
Primary

- Appendix O: Cell 2 Geomembrane Repair Summary Logs
  Secondary
  Primary

- Appendix P: Cell 2 Geomembrane Seam and Panel Repair Location Logs
  Secondary
  Primary

- Appendix Q: Cell 2 and Cell 3 Leachate Conveyance System Test Logs
  Aggregate Base
  Concrete Test Results
  Hydrostatic Pressure Test Results
  OSDF Equipment Wash Geosynthetics Logs

- Appendix R: Cell 2 Record Drawings
  Top of Subgrade
  Top of Compacted Clay Liner
  Top of Leak Detection Layer
  Top of Leachate Collection Layer
  Top of Protective Layer
  Geomembrane Panel Layout
    Secondary
    Primary

- Appendix S: Requests for Clarification of Information (RCI)
  OSDF Phase II Cell 2

- Appendix T: Design Change Notices (DCN)
  OSDF Phase II Cell 2
  OSDF Phase I Cell 1
  Leachate Conveyance System

- Appendix U: Cell 2 Nonconformance Reports (NCR)
  GeoSyntec Consultants
  Fluor Daniel Fernald
  Petro Environmental Technologies

## 3.2 Personnel

### 3.2.1 Project Personnel

Senior personnel or representatives for the firms involved in the project are as follows:

Fluor Daniel Fernald

- John J. Berretz, Engineer/Geologist, P.G.
- Charles D. Brown, Safety & Health
- Robert D. Crowley, Radiological Field Support
- Jeffrey R. Ellis, Construction Engineer
- Donald A. Fleming, Industrial Hygiene
- David Fox, CADD Operator
- Michael W. Godber, QA/QC Team Leader
- Donald B. Goetz, Construction Engineer, OSDF
- Kevin S. Harbin, Construction Engineer
- Mathew C. Harper, Construction Engineer
- Richard E. Heath, Engineering, P.E.
- Michael J. Hickey, Project Coach, P.E.
- Richard A. Holbrook, Contracts and Acquisition Team Leader
- James C. Jenkins, Engineering, P.E.
- Gregg K. Johnson, Safety & Health Team Leader
- Uday A. Kumthekar, Engineering Team Coach, P.E.
- Jeffrey A. Middaugh, Safety & Health
- Gregory R. Peters, Construction Coordinator

- Daniel H. Stempfley, Radiological Engineering
- Phillip G. Thomas, Safety & Health
- Robert M. Turnbull, Construction Coordinator
- James T. Turner, Quality Assurance
- Charles C. VanArsdale, Engineering, P.E.
- Muriel K. Vigus, Quality Assurance
- Paul J. Volker, Quality Assurance
- Louis R. Wehlitz, Construction Team Leader
- William A. Zebick, Construction Team Coach

GeoSyntec Consultants (CQA Consultant)

- R. Bonaparte, Ph.D., P.E., Program Manager
- J. Beech, Ph.D., P.E., Responsible Corporate Official
- D. Bodine, P.E., Project Manager
- Kwasi Badu-Tweneboah, Ph.D., P.E. Resident Engineer
- K. Cargill, P.E., Design Team Leader
- D. Phillips, P.E., Project Coordinator
- C. Sukow, CQA Site Manager
- S. Quammen, Site Safety and Health Officer

GeoSyntec's Geomechanical and Environmental
Laboratory (GEL)(off-site geotechnical laboratory)

- N. Rad, Ph.D., P.E., Laboratory Manager
- B. Sigmon, Program Manager/Quality Control Manager
- J. Stalcup, Operations Manager

GeoSyntec's Soil-Geosynthetic Interaction Testing
Laboratory (SGI)(off-site soil-geosynthetic interaction testing)

- R. Swan, Jr., Laboratory Manager
- Z. Yuan, Jr., Quality Control Manager

GeoSyntec's Materials Testing
Laboratory (MTL)(off-site geosynthetics testing laboratory)

- T. Peel, Laboratory Manager
- B. Tindell, Program Manager
- D. Carlson, Quality Control Manager

Hirsch and Associates (Surveyor, OSDF Phase I and Phase II)

- Lynn Hirsch, Registered Surveyor

Petro Environmental Technologies, Inc. (Contractor, senior personnel only)

- Mark Mather, President and Project Manager
- Pete Bolig, Safety & Health Officer
- Jeff Browning, Labor Steward
- Jill Hibbard, Project Administrator
- Lee Oliver, Labor Foreman
- Rick Schairbaum, QC Manager
- John Stacey, Field Superintendent
- Dave Williams, General Superintendent
- Jerry Istere, Geosynthetics QC
- Bill Witte, Clay Liner QC
- Brian Erismen, Impacted Material QC

Solmax Geosynthetics, Inc.,. (Geosynthetic Installer)

- Marc Micochero, Superintendent
- John Allen, Master Seamer

Village Building Services, Inc. (Leachate Conveyance System Repair)

- Marvin Brooks, Superintendent

### 3.2.2 GeoSyntec's On-Site Personnel Schedules

GeoSyntec project personnel were present on site according to the following schedules:

| | |
|---|---|
| • J. Beech, Ph.D., P.E., Responsible Corporate Official | 19-21 Aug 1998, 21 Oct 1998 |
| • K. Cargill, P.E., Design Team Leader | 08 April 1998 and 11-13 May 1998 |
| • Dan Bodine, P.E., Project Manager | 06-08 Jan 1998, 06 April 1998 - Dec 1998 |
| • Dave Phillips, P.E., Project Coordinator | 04–05 June 1998, 28–30 Oct 1998, 14-18 Dec 1998 |
| • Kwasi Badu-Tweneboah, P.E., Resident Engineer | 15 June 1998 – 14 Aug 1998, 31–04 Sept 1998, 05-09 Oct 1998 |
| • Collin Sukow, CQC Site Manager | 30 April 1998 – Dec 1998 |
| • Jim Burnett, Senior Project Engineer | 04-06 Nov 1998, 16-20 Nov 1998 |
| • Dave Evans, Senior Engineering Technician | 03 Aug 1998 – Dec 1998 |
| • Brian Erisman, Engineering Technician | 05 Jan 1998 – 02 July 1998 |
| • Rodney Hummel, Engineering Technician | 27 May 1998 – Dec 1998 |
| • Mike Humphreys, Engineering Technician | 21 Aug 1998 – Dec 1998 |
| • H. E. Meekins, Senior Engineering Technician | 30 March 1998 – 20 Aug 1998 |
| • Bill Nagel, Senior Engineering Technician | 02 Jan 1998 – 13 Jan 1998 |
| • Rob Peddicord, Engineering Technician | 02 Jan 1998 – Dec 1998 |
| • Scott Quammon, Senior Engineering Technician | 20 July 1998 – Dec 1998 |
| • Byron York, Senior Engineering Technician | 08 Sept 1998 – 02 Dec 1998 |
| • Renee Erisman, Office Assistant | 05 Jan 1998 – Dec 1998 |

# 4 CONSTRUCTION QUALITY ASSURANCE – 1998 PHASE I AND PHASE II EARTHWORK

## 4.1 General

GeoSyntec monitored the construction of the earthwork components associated with the OSDF Phase I and Phase II projects. The OSDF Phase I project components completed during 1998 consisted of Cell 1 compacted clay wedge layer, access corridor and the equipment wash facility. The OSDF Phase II project components completed during 1998 consisted of Cell 2 liner system and initial development of the clay borrow area. Different earthwork materials were used to construct the various components of the projects. These materials included existing subgrade material, compacted fill, compacted clay liner, granular drainage material for the LDS and LCS layers, embedment fill, aggregate base material and the protective layer placed over the liner system composite. The earthwork construction activities using these materials are generally described below.

- Cell 2 subgrade was initially rough graded. The subgrade surface was proof rolled by using a loaded articulated dump truck and visually monitored by CQA personnel. Isolated areas of soft or loose materials were either dried and compacted or undercut and replaced with fill material which was compacted as described below.

- The cell floor was graded to achieve the required subgrade elevations. The subgrade areas that required filling were proof rolled prior to fill placement to detect excessively soft or loose zones. Soft or loose zones were excavated prior to placement of fill. The fill material consisted of compacted fill, which was obtained from cut areas in the cell, or other on-site borrow sources within the construction area. The compacted fill was placed in approximately 7 in. to 12 in. (180 mm to 305 mm) thick (maximum) loose lifts and compacted to a minimum degree of compaction of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test (i.e., American Society for Testing and Materials (ASTM D 698). The fill was compacted at a moisture content between 3 percent dry and 3 percent wet of the optimum moisture content measured in the standard Proctor compaction test.

- The Cell 2 perimeter berms were also constructed using compacted fill. The fill was placed in approximately 8 in. (200 mm) thick (maximum) loose lifts and compacted as described above.

- The 36 in. (0.9-m) thick Cell 2 compacted clay liner was constructed using 8 in. (200 mm) thick (maximum) loose lifts; with exception of the first lift which was placed as a 12 in. (0.3-m) loose lift. This initial 12-inch loose lift resulted in a compacted lift of about six inches (measured to the bottom of the pad foot indentation) and about three inches of material between compactor foot indentations (material which was included in the second lift). The compacted clay material was obtained from the area contained within the Cell 2 and future Cell 3 footprints. Each lift was compacted to a minimum degree of compaction of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test (i.e., ASTM D 698). The clay liner was compacted at a moisture content between zero and 3 percent wet of the optimum moisture content measured in the standard Proctor compaction test. The field moisture content and dry unit weight were also required to fall within the acceptable permeability zone (APZ) as established by the test pad program and defined in the Technical Specifications. The APZ criteria are used to assure a hydraulic conductivity of less than $1 \times 10^{-7}$ cm/s. Clay materials used in the compacted clay liner were approved through conformance testing which included hydraulic conductivity testing of remolded compacted clay samples in the off-site geotechnical laboratory.

- The granular components of the Cell 2 liner system, which included a 12 in. (0.3-m) thick LDS layer and a 12 in. (0.3-m) thick LCS layer were constructed using material obtained from off-site borrow sources. Each material was placed in one loose lift and compacted using low ground pressure equipment.

- The compacted clay layers for the Cell 1 and Cell 2 clay wedges were constructed using 9 in. (200mm) thick (maximum) loose lifts. Each lift was compacted to a minimum degree of compaction of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test (i.e., ASTM D 698). The wedge clay layers connecting the cell clay liner and future clay cap were compacted at field moisture contents and dry unit weights falling within the APZ as defined in the Technical Specifications. The APZ criteria are used to assure a hydraulic conductivity of less than 1 x $10^{-7}$ cm/s. Clay materials used in the compacted clay wedge were clay liner material approved through conformance testing which included hydraulic conductivity testing of remolded compacted clay samples.

- Upon completion of the composite liner system, including the geosynthetics and drainage materials, GeoSyntec issued an interim certification letter for these components prior to placement of the protective layer. The protective layer was placed using soil or soil like impacted materials in a single 12-inch lift compacted with a medium sized bull dozer.

CQA personnel observed these earthwork construction activities and tested the soil materials to confirm that the material properties conformed to the project documents, that the specific lift thicknesses were not exceeded, and that the materials were compacted in accordance with the project documents. Geotechnical soil tests were performed in accordance with project documents. The testing was performed either: (i) in-place; (ii) on-site, in the geotechnical laboratory; or (iii) off-site, at GeoSyntec's GEL in Alpharetta, Georgia.

## 4.2 Changes in Earthwork Specifications

Requests for Clarification of Information (RCI) and Design Change Notices (DCN) of the earthwork drawings and specifications were processed and approved according to procedures described in FEMP document number ED-12-5002 entitled "Engineering Design Change Process and CQA Plan." RCIs and DCNs were approved, as appropriate by the design organization. Copies of the RCIs and DCNs for Cell 2 are presented in Appendices S and T, respectively.

## 4.3 Conformance Activities

Soil samples were obtained from proposed sources, generally prior to construction, to verify conformance with the project specifications for each material type. Also during construction, soil samples were obtained from the delivered material as required by the project documents. CQA personnel obtained representative samples of material used for compacted fill, compacted clay liner material, and granular drainage materials to be used in the LDS and LCS drainage layers from the appropriate source depending on the material type.

Compacted fill material used in Cell 2 construction was obtained from on-site borrow areas within active construction areas. Compacted clay liner material was obtained from on-site borrow areas and within the Cell 3 footprint and the new on-site borrow area located south of the OSDF cell area. The granular drainage material was obtained from an off-site source. The LCS and LDS drainage layer (No. 78 stone) was obtained from a site known as Highland Stone Quarry located in Hillsboro, OH. The LCS and LDS drainage corridor material (No. 57 stone) was obtained from Martin Marietta, located in Fairfield, OH.

In accordance with the project documents, a series of geotechnical tests were performed on the soil samples to confirm that the following requirements were met.

- Compacted fill material used in construction classified as GC, SC, SM, ML, CL or CH according to the Unified Soil Classification Systems (USCS) when evaluated in accordance with ASTM D 2487 and the maximum particle size was 5 in. (130 mm). Compacted fill was also used to backfill the excavations for the Leachate Conveyance System repair.

- Compacted clay liner material used in construction was classified as CL or CH according to the USCS when evaluated in accordance with ASTM D 2487; had a maximum particle size of 2 in. (50 mm); a plasticity index (PI) between 10 and 40 when tested in accordance with ASTM D 4318; and hydraulic conductivity (i.e., permeability) of $1.0 \times 10^{-7}$ cm/s or less, when evaluated in accordance with ASTM D 5084. The perimeter berm anchor trench backfill had the same requirements as the compacted clay liner material.

- The granular drainage material used in construction of the LCS and LDS layers was classified as GP according to the USCS when evaluated in accordance with ASTM D 2487; had 100 percent passing a 0.75 in. (19 mm) opening sieve when tested in accordance with ASTM C-136; met gradation requirements for modified No. 78 stone; had a carbonate content of less than or equal to 5 percent when tested in accordance with ASTM D 3042 at a pH of 4; the hydraulic conductivity (i.e., permeability) requirement was 1.0 x $10^{-1}$ cm/s or greater when evaluated in accordance with ASTM D 2434.

- The granular drainage material used in construction of the LCS and LDS corridors classified as GW or GP according to the USCS when evaluated in accordance with ASTM D 2487; had 100 percent passing a 1.5 in. (38 mm) opening sieve when tested in accordance with ASTM C-136; met gradation requirements for modified No. 57 stone; had a carbonate content of less than or equal to 5 percent when tested in accordance with ASTM D 3042 at a pH of 4; the hydraulic conductivity (i.e., permeability) requirement was 10.0 cm/s or greater when evaluated in accordance with ASTM D 2434.

A description of the geotechnical tests and results are described in Section 4.5 of this report. Construction of the perimeter berm anchor trench is described in Section 4.6.2 of this report.

## 4.4 Field Monitoring Activities

### 4.4.1 General

GeoSyntec's CQA personnel monitored the placement of soil as previously described. The on-site personnel monitored those operations considered critical to the performance of the liner system. Potentially nonconforming or questionable practices observed by CQA personnel were brought to the attention of the Construction Manager for review and correction.

### 4.4.2 Excavation

CQA personnel monitored excavation operations within the Cell 2 work areas. Topsoil, organic matter (i.e., stumps, roots, or vegetation), and any other deleterious material unsuitable for foundation material was excavated prior to construction of the liner system and stockpiled on-site.

### 4.4.3 Compacted Fill

CQA personnel monitored the placement of the compacted fill for the cell subgrade, perimeter berms, and other areas requiring fill material. Areas receiving fill and areas which were cut to subgrade elevations were proof rolled by the contractor to detect soft or loose zones. Proof rolling was performed using a loaded articulated dump truck. In areas where soft or loose materials were detected, the areas were undercut and compacted fill was placed. In cut areas and during proof rolling, the surface was monitored by CQA personnel to confirm that potential deleterious materials were removed. In areas where the fill was extended from previous construction, the previously compacted fill was cut back, in order to establish a key-in, prior to the construction of the extension.

The compacted fill material was placed in controlled lifts (as described previously) using articulated dump trucks and using a Caterpillar D-6R bulldozer to spread the material. The horizontal lifts were then compacted using a Caterpillar 815 padfoot compactor. When there was inclement weather which impacted the exposed lift of compacted fill, prior to further placement of subsequent lifts, the surface of the top lift was scarified using the tracks of a bulldozer.

### 4.4.4 Compacted Clay Liner

After completing the compacted fill grading operations, CQA personnel observed the placement of the compacted clay liner material. Construction of the compacted clay liner was in accordance with the project documents and patterned after the Test Pad Program. The results of the test pad program were used to develop the specifications for compacted clay liner materials and construction. The test pad program is described in a report entitled "Test Pad Program Final Report, Revision 0, dated June 1997." A Test Pad Program Final Report Addendum was submitted in October 1998 and accepted by USEPA on 2 December 1998. This addendum modified the left boundary of the APZ from the 90% degree of saturation to a line defined by the "line of optimums" for the clay liner material. The construction sequence of the compacted clay liner is described below:

- after stripping the topsoil at the source, the clay was excavated and processed on-site using a bar screening plant and stockpiled in preparation for transportation to the cell construction site;

- a water bar attachment on the screening plant added water to the material to increase the moisture content, as needed;

- the cell floor surface and the top surface of each lift of compacted clay was scarified using a soil stabilizer; the sideslopes of the cell and top surface of each lift of compacted clay on the sideslopes was scarified with the tracks of a Caterpillar D-6R bulldozer;

- the compacted clay material was hauled from the stockpile by articulated dumps and placed in the cell;

- the compacted clay was spread in approximately 7 in. to 9 in. (180 mm to 230 mm) thick (loose) lifts using a D-6R bulldozer equiped with a laser guided leveling system;

- after spreading, a soil stabilizer (RACO 250) was used to break up clods of compacted clay; water was added to increase the compacted clay's moisture content as required;

- after each lift was stabilized using the soil stabilizer visible rock particles greater than 2 inches were removed by laborers;

- each lift of compacted clay was compacted using a Caterpillar 815 padfoot compactor making a minimum of six passes;

- lift thickness was controlled for the first lift by grade stakes placed by the contractor at an approximate spacing of 50 ft (15 m); CQA personnel visually monitored the placement and compaction of the compacted clay relative to these stakes to provide a check of lift thickness; the stakes were removed immediately before the material adjacent to the stakes was compacted; subsequent lifts were visually monitored by the contractor using traffic cones for grade control;

- a D-6R bulldozer was used to grade the compacted clay material;
- the final grade was rolled with a vibratory smooth drum roller to seal the top surface of the compacted clay; and
- after final grading of the compacted clay surface, the surveyor confirmed final grade elevations;

The contractor periodically added water during or after compacted clay placement to limit drying or desiccation cracking of the compacted clay surface. Prior to deployment of the GCL, the compacted clay liner was visually inspected by the installer and CQA personnel for surface cracks. If significant drying or cracking of the compacted clay surface was observed, the contractor was instructed to moisture condition and rework the affected area.

### 4.4.5 Leak Detection System Layer

CQA personnel monitored the placement of the LDS layer for Cell 2. The 12 in. (0.3-m) thick LDS layer was constructed using granular drainage material obtained from Highland Stone. The method of placement and the CQA procedures during construction of the LDS layer were similar to the methods and procedures used during construction of the LCS layer, discussed below.

It is noted that the same material was used in the LDS drainage layer as the LCS layer, which is discussed below. In addition, a leachate collection pipe was installed in the LDS layer. The pipe was surrounded by LDS drainage corridor aggregate.

### 4.4.6 Leachate Collection System Layer

CQA personnel monitored the placement of the LCS drainage layer and corridor material for Cell 2. The 12 in. (0.3-m) thick LCS layer was constructed using granular drainage material obtained from Highland Stone. The granular drainage material was stockpiled in an area south of the construction area. The LCS drainage corridor was constructed using granular drainage material obtained from Martin Marietta. The granular drainage material was stockpiled in an area south of the construction area.

The construction sequence of the LCS layer was as follows:

- Caterpillar or Volvo articulated dump trucks hauled the granular drainage material from the stockpile to the cell area using a minimum 3-foot thick haul road constructed of LCS material;

- the granular drainage material was spread in approximately one 12 in. (250 mm) thick (loose) lift using Caterpillar D-6R LGP wide-track bulldozers; and

- a contractor's laborer was utilized during the fill-spreading operation to control and prevent wrinkle formation in the underlying geosynthetics.

During placement of the LCS layer, CQA personnel monitored the contractor's activities to assure that geomembrane wrinkling and the risk of damage to the underlying geomembrane was minimized. CQA personnel also confirmed that the contractor operated bulldozers in areas where at least a 1-ft (0.3-m) thick layer of granular drainage material was maintained over the geomembrane, and that a 3-ft (0.9-m) thick layer of granular drainage material was maintained over the geomembrane in heavily traffic areas.

In addition, a leachate collection pipe, a redundant collection pipe and a horizontal well were installed in the LCS layer. The pipes were surrounded by LCS drainage corridor aggregate.

### 4.4.7 Protective Layer

CQA personnel monitored the placement operations for the protective layer. The protective layer was constructed using impacted material obtained from on-site Active Fly-Ash Stockpile. The protective layer was placed in a 12 to 15 in (300 to 380 mm) thick loose lift and was tracked with a medium sized bulldozer.

### 4.4.8 Phase 1 Construction Completion Work Items

CQA personnel performed monitoring and testing activities for completion-construction of the access corridor, the impacted material haul road adjacent to the OSDF, and the OSDF decontamination facility during 1998. CQA monitored the additional material placement and compaction of the subbase and base road material for the access corridor and impacted material haul road. CQA also monitored the installation of the OSDF decontamination facility which included monitoring of drainage aggregate, 60 mil textured GML, drainage sump installation and geotextile cushion.

## 4.5 Field Testing Activities

### 4.5.1 Geotechnical Testing

As part of CQA activities, geotechnical testing was performed on each of the soil components of the Cell 2 double-composite liner system. Depending on the specific test, testing was performed in-place or at either the on-site or off-site geotechnical laboratory. The following geotechnical tests were performed.

- In-place nuclear moisture/density tests were performed on compacted lifts of compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 2922 and ASTM D 3017.

- Standard Proctor compaction tests were conducted on the soils used for compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 698.

- Moisture content tests were performed on samples of compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 2216.

- Grain-size distribution tests were conducted on the soils used for compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 422. Atterberg limits tests were conducted on the soils used for compacted clay liner material. The tests were performed in general accordance with ASTM D 4318. The Unified Soil Classification System (USCS) was used to classify the material in accordance with ASTM D 2487.

- Carbonate content tests and hydraulic conductivity tests were conducted on the LCS and LDS drainage layers and LCS and LDS corridor material. The tests were performed in general accordance with ASTM D 3042 and ASTM D 2434, respectively.

- Hydraulic conductivity tests were performed on the compacted clay liner material. The hydraulic conductivity tests on compacted clay liner material were conducted in accordance with ASTM D 5084.

A summary of the results of the geotechnical laboratory tests is presented in Appendix F. The results of the in-place nuclear moisture/density tests are presented in Appendix G. GeoSyntec supplied two calibrated nuclear gauges (i.e., Troxler models 3430 and 3440) for Cell 2 construction, which were used to perform the moisture/density tests for Phase II construction. The results of the nuclear moisture/density tests were verified periodically, by comparing the tests with results observed using the sand cone method (ASTM D 1556) or the drive cylinder method (ASTM D 2937) and with oven moisture content tests. A moisture calibration factor (in accordance with ASTM D 3017) was developed for compacted clay liner material based on oven moisture content tests. The data are presented in Appendix G to support the field density test data.

A grid layout of the site was used to visually locate the in-place tests and sample locations. Only visual positioning of test locations was used. Therefore, the locations and elevations (if given) of the tests and samples reported in the appendices are approximate.

### 4.5.2 Compacted Fill

Compacted fill was compacted to a minimum degree of compaction of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test. CQA personnel conducted in-place nuclear moisture/density tests at a minimum frequency of two (2) tests per acre per lift of soil. A total of 79 field moisture/density tests were performed in the Cell 2 area. Of these, eight (8) tests failed to meet the minimum percent compaction requirement. In each case of a failing test, the contractor reworked and recompacted the area surrounding the failure and then CQA personnel retested the area. This procedure was repeated until satisfactory moisture/density test results were obtained in each location. The results of the field moisture/density tests are presented in Appendix G.

In addition to the in-place testing, seven (7) representative samples were obtained for laboratory testing during construction. A summary of the testing requirements is presented in Table 4-1. Geotechnical test results are presented in Appendix F.

### 4.5.3 Compacted Clay Liner/Clay Cap

CQA personnel performed in-place nuclear moisture/density tests at a minimum frequency of 5 tests per acre per lift of the compacted clay liner/clay cap. This included Cell 2 clay liner and completion of the clay wedge (clay cap) for Cell 1. A total of 528 field moisture/density tests were performed. A total of 123 tests failed to meet the minimum degree of compaction requirement of 95 percent of the maximum dry unit weight at less than 3 percent over optimum moisture content, as determined by the standard Proctor compaction test and within the acceptable permeability zone (APZ). Fourteen (14) tests were evaluated incorrectly by CQC by prematurely using the proposed line of optimums APZ presented in the Test Pad Program Final Report Addendum (refer to discussion in Section 4.4.4). All but two (2) of these tests passed the modified APZ, which has since been approved. Nineteen (19) other tests recorded as passing tests actually had moisture contents slightly above the 3 percent over optimum limit. All these tests have been addressed during construction in GeoSyntec NCR Nos. 20102-002, 20102-004, 20102-007 and 1702-012. NCR's are provided in Appendix U. For the 109 remaining failed test the contractor reworked and recompacted the area surrounding the failure and then the area was retested by CQA personnel. This process was repeated until moisture/density test results met specifications. The two tests that fell slightly outside the APZ and those slightly above 3 percent above optimum all were compacted to minimum 95 percent compaction and are not significant to the performance of the compacted clay liner. The results of the field moisture/density tests are presented in Appendix G. A summary of compacted clay liner/cap properties is presented in Table 4-2.

Off-site geotechnical laboratory hydraulic conductivity tests were performed on remolded samples of the compacted clay liner. Samples were obtained during cell construction on a minimum frequency of one per 1,500 cubic yards (1,150m$^2$) of clay liner material. A total of three (3) samples failed to meet the hydraulic conductivity criterion of 1 x $10^{-7}$ cm/s or less. These three (3) samples, when inspected by the lab technician, had a honeycomb structure. As a result of the observed inappropriate soil matrix, the samples were remolded and retested meeting the minimum hydraulic conductivity value of 1 x $10^{-7}$ cm/s or less. The laboratory test results are presented in Appendix F.

As part of the CQA activities for the compacted clay liner, CQA personnel periodically checked the clay's moisture content at the stockpile. The adequacy of the lift thickness and the bonding between lifts were checked by hand auguring test holes at random locations. These test holes, as well as the holes left at the moisture/density tests, were filled with bentonite granules and compacted clay material. The mixture was manually compacted in the holes using a steel rod.

In addition to the geotechnical testing described above, index tests were performed on the clay material as required by the project documents. Index tests were performed at a minimum frequency of one set per 1,500 cubic yards (1,150 $m^2$) of stockpiled material. A total of 35 grain-size distribution tests and 35 Atterberg limit tests were performed on the compacted clay liner material to verify that the consistency of the material corresponded to the requirements of the Technical Specification. The tests indicated a variation in the plasticity index between 10 and 40. The tests indicate a minimum clay content of 18 percent. The grain-size distribution tests all resulted in a classification of CL for this material, according to the USCS. The results of these tests are presented in Appendix F.

Following confirmation of the test results, and prior to deployment of the GCL and geomembrane liner, the surface of the compacted clay liner was visually observed by the installer and CQA personnel for surface cracks. If significant drying or cracking of the surface was observed, the contractor was instructed to moisture condition and rework the affected area.

# TABLE 4-1

## PHASE II 1998 COMPACTED FILL MATERIAL PROPERTIES SUMMARY

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED[2] | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size: Sieve | ASTM D 422 | 100% Finer than 5.0 inch | 1 per 1,500 | 6 | 7 |
| Compaction | ASTM D 698 | — | 1 per 1,500/ as required | 6 | 7 |
| Moisture | ASTM D 2216<br>ASTM D 4643 | — | 1 per 1,500/ as required | 6 | 7 |
| Soil Classification | ASTM D 2487 | GC, SC, SM, ML or CL | 1 per 1,500 | 6 | 6 |
| Atterberg Limits | ASTM D 4318 | — | 1 per 1,500 | 6 | 6 |
| FIELD TEST | | | | | |
| Sand Cone or Drive Cylinder<br>Soil density(Sand Cone)<br>Soil moisture(Sand Cone)<br>Soil density (Drive Cyl.)<br>Soil moisture (Drive Cyl.) | ASTM D 1556<br>ASTM D 2216<br>ASTM D 2937<br>ASTM D 2216 | ...<br>...<br>...<br>... | 1 per 25 passing density tests | 3 | 3 |
| Nuclear Gauge:<br>Soil density<br>Soil moisture | ASTM D 2922<br>ASTM D 3017 | ≥95%<br>± 3% O.M.C. | 2/acre/lift | 20 | 79 (8) |

NOTES: (1) Reference Section 02200 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total volume of 8,000 $yd^3$ for the Phase II cell 2 construction.

# TABLE 4-2

## PHASE II CELL 2 COMPACTED CLAY LINER PROPERTIES SUMMARY INCLUDING PHASE 1 CELL 1 CLAY WEDGE

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED[2] | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size: | ASTM D 422 | | 1 per 1,500 | 32 | |
| Sieve | | | | | |
| Percent Finer than 2.0 in. | | 100% | | | 35 |
| Percent Finer than .75 in. | | ≥90% | | | |
| Hydrometer | | | | | |
| Percent Finer than #200 | ASTM D 1140 | ≥50% | | | 35 |
| Percent Finer than .002 mm | | ≥15% | | | |
| Compaction | ASTM D 698 | — | 1 per 1,500/ as required | 32 | 43 |
| Moisture | ASTM D 2216<br>ASTM D 4643 | — | 1 per 1,500/ as required | 32 | 108 |
| Soil Classification | ASTM D 2487 | CL or CH | 1 per 1,500 | 32 | 35 |
| Atterberg Limits | ASTM D 4318 | 10 ≤PI > 40 | 1 per 1,500 | 32 | 35 |
| Hydraulic Conductivity:<br>Source<br>Remold | ASTM D 5084 | $> 1 \times 10^{-7}$ cm/sec | 1 per 1,500 | 32 | 34 |
| FIELD TEST | | | | | |
| Sand Cone:<br>Soil density<br>Soil moisture | <br>ASTM D 1556<br>ASTM D 2216 | — | 1 per 25 passing density tests | 16 | 22 |
| Nuclear Gauge or Drive Cylinder<br>Soil density<br>Soil moisture | ASTM D2992<br>ASTM D 2937<br>ASTM D 3017 | Within APZ and ≥95%<br>M.C. 0 - 3% O.M.C. | 5/acre/lift | 280 | 528 (123) |
| Depth Verification<br>Survey | | | | | |

NOTES: (1) Reference Section 02225 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a stockpile volume of $48{,}000 yd^3$ for the Phase II Cell 2 construction and Phase 1 Cell 1 Clay Wedge.

### 4.5.4 Leak Detection System Layer

The 1.0-ft (0.3-m) thick leak detection system (LDS) layer was constructed using granular drainage material. The material was spread on top of the geotextile cushion and geomembrane secondary liner. This layer of the liner system had the same CQA requirements as the LCS layer, discussed below.

GeoSyntec personnel performed on-site laboratory and off-site laboratory geotechnical testing on the granular drainage material used for the LDS layer as part of the CQA activities during Cell 2 construction. These tests were identical to those for the LCS layer, as described in the next section.

Grain-size distribution tests were performed on representative samples obtained from the on-site stockpiles. GeoSyntec also performed off-site laboratory permeability tests and carbonate tests on representative samples of the granular drainage material. A summary of the testing requirements for granular drainage material for the drainage layer is presented in Table 4-3. A summary of the testing requirements for granular drainage material for the drainage corridor is presented in Table 4-4. Geotechnical laboratory test results are presented in Appendix F.

### 4.5.5 Leachate Collection System Layer

The 1.0-ft (0.3-m) thick leachate collection system (LCS) layer on the geomembrane primary liner of the cell was constructed using granular drainage material. The material was spread on top of the geotextile cushion and the geomembrane primary liner as previously described in Section 4.4.6. It is noted that this material was used in both the LCS and LDS layer that was discussed above.

GeoSyntec performed on-site laboratory and off-site laboratory geotechnical testing on the granular drainage material used for the LCS and LDS layers as part of the CQA activities during Cell 2 construction. On-site and off-site laboratory grain-size distribution tests were performed on 10 samples obtained from the on-site stockpile. The LCS and LDS drainage layer material was classified as a GW or GP, based on the USCS. The laboratory grain-size distribution test results are presented in Appendix F.

GeoSyntec also performed off-site laboratory hydraulic conductivity tests and carbonate tests on representative samples of the granular drainage material. A summary of the testing requirements for granular drainage material for the drainage layer is presented in Table 4-3. A summary of the testing requirements for granular drainage material for the drainage corridor is presented in Table 4-4. Geotechnical laboratory test results are presented in Appendix F.

### 4.5.6 Protective Layer

The 12 in. (0.3-m) thick protective cover was constructed using impacted material as described in the Impacted Material Placement Plan (IMPP). The material was spread on top of the geotextile filter and LCS granular drainage material.

To protect the underlying liner system from construction damage, the protective layer was tracked with a medium-sized bulldozer.

CQA personnel monitored transporting, placing, tracking and final surveying of the protective layer to verify conformance with the IMPP and the CQA Plan. CQA personnel signed the manifest and documented that placement was in accordance with the IMPP and CQA Plan.

## 4.6 Soil Anchorage of Geosynthetics

### 4.6.1 General

GeoSyntec's CQA personnel monitored the placement of material for anchorage for the geosynthetic material around the perimeter of the cell. Compacted clay liner material was used to provide the permanent anchorage of the double-liner system. Details of the anchoring are presented in the two subsections that follow.

# TABLE 4-3

## PHASE II CELL 2 GRANULAR FILTER MATERIAL (LCS AND LDS DRAINAGE LAYER) NO. 78 STONE

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED[2] | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size:<br>Sieve | ASTM C 136 | 3/4 in. 100<br>1/2 in. 80-100<br>3/8 in. 40-75<br>No. 4 5-25<br>No. 8 0-10<br>No. 16 0-5<br>No. 200 0-2 | 1 per 3,000 | 10 | 10 |
| Soil Classification | ASTM D 2487 | GP | 1 per 3,000 | 10 | 10 |
| Carbonate Content | ASTM D 3042 | ≤5% | 1 per 5,000 | 6 | 6 |
| Hydraulic Conductivity:<br>Granular | ASTM D 2434 | $\geq 1 \times 10^{-1}$ cm/sec | 1 per 3,000 | 10 | 10 |
| FIELD TEST | | | | | |
| Depth Verification:<br>Survey | | | | | |

NOTES: (1) Reference Section 02710 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total volume of 29,000 $yd^3$ for the Phase II construction.

# TABLE 4-4

## PHASE II CELL 2 GRANULAR FILTER MATERIAL (LCS AND LDS DRAINAGE CORRIDOR) NO. 57 STONE

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED[2] | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size: Sieve | ASTM C 136 | 1 1/2 in. 100<br>1in. 95-100<br>1/2 in. 25-60<br>No. 4 0-10<br>No. 8 0-5<br>No. 200 0-2 | 1 per 3,000 | 1 | 2 |
| Soil Classification | ASTM D 2487 | GP | 1 per 3,000 | 1 | 2 |
| Carbonate Content | ASTM D 3042 | ≤ 5% | 1 per 5,000 | 1 | 1 |
| Hydraulic Conductivity: Granular | ASTM D 2434 | ≥ 10 cm/sec | 1 per 3,000 | 1 | 2 |
| FIELD TEST | | | | | |
| Depth Verification: Survey | Visual | As shown on drawings | — | — | — |

NOTES: (1) Reference Section 02710 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total volume of 2,400 $yd^3$ for the Phase II construction.

### 4.6.2 Perimeter Anchor Trench

As required by the project documents, an anchor trench was constructed around the perimeter of the Cell 2 construction area. The construction sequence of the perimeter anchor trench was as follows:

- two 2-ft wide by 2-ft deep (0.6-m wide by 0.6-m deep) secondary and primary anchor trenchs were excavated along the Cell 2 perimeter berms, at specified distances from the crest of the slope;

- the geomembrane secondary liner system (i.e., GCL geomembrane, and geotextile) was subsequently placed in the secondary anchor trench; lifts of compacted clay material were placed over these material and compacted;

- the geomembrane primary system (i.e., GCL, geomembrane, and geotextile) was placed in the primary anchor trench behind the secondary geosynthetics, and lifts of compacted clay material were placed into the anchor trench and compacted; and

- the 7-oz geotextile filter was anchored above the anchor trench during the clay wedge placement.

The general construction procedure for placing and compacting the compacted clay material in the perimeter anchor trench was as follows:

- backfill material was obtained from the processed stockpile and placed in the excavated trench using backhoes;

- backfill material was placed in the anchor trench for the first lift in 10- to 12 in. (250- to 300 mm) thick loose lifts and in subsequent lifts in approximately 6 in. (150 mm) thick loose lifts; and

- the backfill material was compacted using a walk behind articulated pad roller.

Anchor trench backfill was compacted to the specifications as previously described for compacted clay liner material. Nuclear moisture/density tests were performed on the compacted clay material in the anchor trench. A summary of the results of the compaction tests and the field moisture/density tests are included with the compacted clay liner properties and field tests in Table 4-2. Test data are provided in Appendix G.

# 5 CONSTRUCTION QUALITY ASSURANCE - PHASE II CELL 2 GEOSYNTHETICS

## 5.1 General

GeoSyntec monitored the installation of the geosynthetic components of the double-composite liner system. Principal field activities are described in Section 3.1.3. The on-site CQA personnel continously monitored those operations that were considered critical to the performance of the liner system. Non-conforming practices observed by GeoSyntec were brought to the attention of the FDF Quality Assurance personnel and the Construction Manager for review and correction.

The total quantity of geomembrane installed during the Cell 2 construction, as measured by CQA personnel, was 645,648 $ft^2$ (59,965 $m^2$), which consists of geomembrane primary liner and geomembrane secondary liner. The primary and secondary geomembrane panel layout drawings are presented in Appendix R.

## 5.2 Changes in Geosynthetic Specifications

Requests for clarification of information (RCI) and design change notices (DCN) of the geosynthetic drawings and specifications were processed and approved according to procedures described in FEMP document number ED-12-5002 entitled "Engineering Design Change Process" and the CQA Plan. These RCIs and DCNs were approved, as appropriate, by the design organization. Copies of the RCIs and DCNs issued for Cell 2 are presented in Appendices S and T, respectively.

Approved RCIs and DCNs for procurement of geosynthetics have been incorporated into revised specifications. As previously indicated, procurement of the geosynthetics was performed by FDF.

## 5.3 CQA of Geosynthetic Clay Liner

### 5.3.1 Conformance Testing and Documentation

A geosynthetic clay liner (GCL) was used in construction of the double-composite liner system. GCLs manufactured by two different suppliers were used in Cell 2. Rolls of Bentofix GCL, remaining on-site after completion of Cell 1 construction, were used in portions of the Cell 2 construction. These Bentofix rolls were manufactured by Bentofix Technologies, Inc. located in Barrie, Ontario. Rolls of Bentomat GCL were also used in the Cell 2 construction and were manufactured by Colloid Environmental Technologies Company (CETCO) in Fairmount, Georgia.

Conformance sampling, testing and data review of the Bentofix GCL occurred during 1997 and were discussed and presented in the CQA Cell 1 Final Report. However for data completeness, the GCL conformance testing corresponding to the approved rolls of Bentofix used in the construction of Cell 2 have been included in Cell 2 Final Report. Sample numbers of Bentofix are GCL-22, GCL-26 and GCL-27, corresponding to Lot Number 97101002 and Lot Number 97102402 .

For the Bentomat GCL procured in 1998, CQA personnel obtained eight (8) conformance samples (sample nos. GCL-30 through GCL-37) from GCL Lot Numbers 199829030, 199830030 and 199839030. A representative from FDF and a representative from GeoSyntec visited CETCO to observe production, review procedures, and sample material. GeoSyntec personnel visited the plant on three separate occasions (16, 20 and 22 July 1998). All of the eight (8) Bentomat conformance samples were obtained at the factory prior to shipment of materials. The sampling frequency exceeded the minimum acceptable sample frequency of one per 100,000 $ft^2$ (9,300 $m^2$) required by the project documents. Conformance samples were forwarded to GeoSyntec's GEL for hydraulic conductivity testing and to GeoSyntec's SGI for direct shear testing. Based on conformance testing results, including supplier's testing, the three lots stated above were approved for construction.

The conformance test results and the manufacturer's quality control (QC) certificates were reviewed by GeoSyntec. For the Bentofix, additional slope stability calculations were performed, using the interface and internal shear strength conformance data, to verify compliance with the design factors of safety. A summary table for Cell 2 GCL approval is presented in Table 5-1. The GCL conformance computation packages corresponding to the Bentofix lots used in Cell 2 are presented in Appendix I. The manufacturer's QC documentation for each GCL manufacturer is presented in Appendix H. GeoSyntec's conformance test results are also presented in Appendix I. A summary of the physical properties of the GCL and the conformance test frequency is presented in Table 5-2.

# TABLE 5-1

## CELL 2 GEOSYNTHETIC CLAY LINER (GCL) CONFORMANCE TESTING APPROVAL SUMMARY

| LOT No. | QA ID No. (1) | Precision ID No. (2) | QA Test (6) Results | QC Test (6) Results | Approved for Construction | Date (3) Approved | No. of Rolls (4) | Square Footage (5) |
|---|---|---|---|---|---|---|---|---|
| 97101002 | 22 | 08 | Pass | Pass | Yes | 10 Nov 97 | 1 Used | 2,325 |
| 97102402 | 26 | NA | Pass | NA | Yes | 14 Nov 97 | 59 Used | 137,175 |
| 97102402 | 27 | NA | Pass | NA | Yes | 14 Nov 97 | 25 Used | 58,125 |
| 199829030 | 30 | 29659<br>AK2524 | Pass | Pass | Yes | 04 Aug 98 | 44 Total<br>1 Unused | 99,000 |
| 199829030 | 31 | 29718<br>AK4198 | Pass | Pass | Yes | 10 Aug 98 | 36 Total<br>1 Unused | 81,000 |
| 199830030 | 32 | 29821<br>Ak4216 | Pass | Pass | Yes | 12 Aug 98 | 43Total<br>4 Unused | 96,750 |
| 199830030 | 33 | 29818<br>AK4230 | Pass | Pass | Yes | 14 Aug 98 | 46 Total<br>5 Unused | 103,500 |
| 199830030 | 34 | 29901<br>AK4256 | Pass | Pass | Yes | 18 Aug 98 | 46 Total<br>1 Unused | 103,500 |
| 199830030 | 35 | 29907<br>AK4270 | Pass | Pass | Yes | 19 Aug 98 | 46 Total<br>5 Unused | 103,500 |
| 199830030 | 36 | 30365<br>AK4285 | Pass | Pass | Yes | 24 Aug 98 | 14 Total | 31,500 |
| 199839030 | 37 | 33303<br>AK2528 | Pass | Pass | Yes | 22 Oct 98 | 4 Total<br>4 Unused | 9,000 |
| | | | | | | | | |

Notes:
1. QA ID No. given is GeoSyntec's GCL number.
2. Precision is FDF's direct shear and permeability test subcontractor.
3. Date given is date GeoSyntec conformance testing approved. FDF's/Manufacturers tests were approved at later date.
4. Number of rolls given is total delivered to site and used in Cell 2 construction, unless otherwise indicated.
5. Square footage for total number of rolls used in Cell 2 for 1997 lots square footage delivered for 1998 lots.
6. QA refers to conformance testing performed by GeoSynte. QC refers to Manufacturers testing. Passing results include, for lots 97101002, and 97102402, slope stability analysis to confirm that Factors of Safety specified during design were met.

# TABLE 5-2

## CELL 2 GEOSYNTHETIC CLAY LINER PHYSICAL PROPERTIES SUMMARY

| DESCRIPTION | TEST STANDARD | MANUFACTURER SPECIFICATIONS[3] | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY[5] (ft²) | |
|---|---|---|---|---|---|
| | | | | Manf. QC | Conformance QA |
| Bentonite Content (lb/ft²) | ASTM D 5993 | 1.0 lb/ft² @ 25% moisture | ≥1.0 | 40,000 | NA |
| Bentonite Moisture Content (%) | ASTM D 4643 | 25% max | ≤25 | 40,000 | NA |
| Direct Shear[4] | ASTM D 5321 | NA | LD Shear - 12°<br>LD Shear - 7°<br>LD Shear - 6.5°<br>Peak Shear - 17° | 100,000 | 100,000 or per lot |
| Grab Elongation (%) | ASTM D 4632 | 10 % Typical | NA | 40,000 | NA |
| Peel Strength (lb) | ASTM D 4632 | 15 min | ≥15 lbs | 40,000 | NA |
| Grab Strength (lb) | ASTM D 4632 | 90 MARV | NA | 40,000 | NA |
| Hydraulic Conductivity (cm/s) ($\sigma'$ = 5 psi) | ASTM D 5887 | $<5\times10^{-9}$ | $<5\times10^{-9}$ | 40,000 | 100,000 |
| Fluid Loss (ml) | ASTM D 5891 | 18 max | ≤18 ml | 40,000 | NA |
| Bentonite Free Swell (ml/2g) | ASTM D 5890 | 24 | ≥24 | 40,000 | NA |

Total No.of Bentomat Rolls Delivered to Site: 274 Total No.of Conformance Samples: 8 Bentomat and 3 Bentofix

Notes:
(1) Reference Section 02772P of the Specifications and Section 8 of the CQA Plan for further details.
(2) Ambient placement temperatures are between 40°F and 104°F. The GCL rolls are overlapped a minimum of 6 in. along edges, with a 12 in. end overlap. No horizontal seams are allowed on the slopes (≥5H:1V). Patches extend 12 in. beyond a defect on ≤5% slope areas and 24 in. on ≥5% slope areas. Bentonite is placed between seams involving Bentomat.
(3) Bentofix and Bentomat are the GCLs used for Cell 2. Roll dimensions are 15.5 ft by 125 ft for Bentofix and 15 ft by 150 ft for Bentomat. Manufacturer's specifications listed in table above are for Bentomat that was the primary GCL used in Cell 2.
(4) Peak Shear Strength and Large-Displacement (LD) shear strength at normal stress of 5, 20, 45 psi, reported as Secant Angle in degrees.
(5) Testing shall be performed at a frequency of one per lot or at listed frequency, whichever is greater. A lot is defined by ASTM D4354.
MD - Machine Direction; XD - Cross Direction; NA - Not Applicable; $\sigma'$ = Effective Confining Stress.

0000052

2058

### 5.3.2 Field Monitoring Activities

#### 5.3.2.1 Delivery and On-Site Storage

Upon delivery, GCL rolls were unloaded in a laydown area located to the northeast of the Cell 1 construction area, stored on dunnage and covered with a tarpaulin. The GCL rolls had a plastic wrapping to protect against water and premature hydration. An all-terrain lift truck or a front-end loader transported the rolls. The rolls were deployed or were temporarily stored adjacent to the construction area prior to deployment. CQA personnel monitored the installer's delivery, unloading, and storage procedures. Potentially nonconforming practices observed by CQA personnel were brought to the attention of the Construction Manager for review and correction. The CQA personnel observed that the material was stored and handled in an appropriate manner or corrective action was taken, where appropriate.

#### 5.3.2.2 Deployment

CQA personnel monitored the deployment of the GCL rolls. During deployment, the CQA personnel checked for the following:

- manufacturing defects;
- evidence of premature hydration of the bentonite;
- damage that may have occurred during shipment, storage, and handling; and/or
- damage resulting from installation activities.

If materials were observed to be damaged, the installer was notified and the damaged materials were either discarded or repaired. CQA personnel observed repair locations, during and after repair.

CQA personnel monitored the deployment of the GCL, as well as its condition after installation, to verify that the installer followed the following procedures:

- prior to deployment, the installer signed a Certificate of Acceptance of subgrade (presented in Appendix J);

- the GCL was unrolled and placed in a manner which kept the roll of GCL in sufficient tension to avoid excessive wrinkling using low ground-pressure rubber-tracked equipment;

- the rolls were deployed with the geotextile printed with the manufacturer's name facing upwards (i.e., woven geotextile up and nonwoven geotextile in contact with the underlying soil component);

- measures were taken to avoid entrapment of stones or other objects in the GCL panels;

- measures were taken to avoid damage to the underlying clay surface during deployment of the rolls;

- measures were taken to keep the GCL free of contamination and protected from premature hydration; and

- geomembrane installation immediately followed installation of the GCL.

After deployment of the GCL, CQA personnel observed that the installer used the following procedures to join adjacent rolls of GCL:

- adjacent GCL panels were overlapped a minimum of 6 in. (150 mm) along the length of the panels and a minimum of 12 in. (300 mm) along the width of the panels; and

- dry bentonite granules was applied, at a minimum rate of one pound per linear foot, around liner penetration boxes and between seams of overlapped panels, as specified by the GCL manufacturer.

Observed holes or tears in the GCL were repaired by the installer by placing a patch of the same material over or under the hole or tear and at a distance of at least 2 ft (0.6 m) beyond the edges of the hole on slopes greater than 5 percent or 1 ft (0.3 m) beyond the edges of the hole or tear on slopes less than 5 percent. In areas where premature hydration of the GCL was detected, the GCL was removed and replaced with new approved material.

## 5.4 CQA of Geomembrane

### 5.4.1 Conformance Testing and Documentation

The 80-mil (2.0mm) thick textured HDPE geomembrane was supplied by GSE Lining Technology, Inc, Houston, Texas. Prior to and during Cell 2 construction, geomembrane conformance samples were taken randomly from the 80-mil (2.0 mm) thick HDPE textured geomembrane rolls used to construct the lining system. A total of 11 conformance samples were obtained by CQA personnel at the manufacturing plant prior to delivery to the site. These samples represented five (5) lots of geomembrane, which comprised 98 geomembrane rolls. The total number of conformance samples exceeds the minimum acceptable sample frequency of one per 100,000 $ft^2$ (9,300 $m^2$) or one per lot as required by the project documents.

The conformance samples were forwarded to GeoSyntec's MTL for testing. The conformance test results and the manufacturer's QC certificates, for each roll, were reviewed by CQA personnel and were found to be in compliance with the project documents. The geomembrane manufacturer's QC documentation included resin and geomembrane certifications and is presented in Appendix H. The geomembrane manufacturer's roll numbers, GeoSyntec's conformance sample logs, and GeoSyntec's conformance test results are presented in Appendix I. A summary of the physical properties of the geomembrane and the conformance test results are presented in Table 5-3.

In addition to geomembrane conformance testing, the project documents specified a manufacturer's certification letter of conformance for the extrudate rod. CQA personnel obtained one letter of certification for the extrudate rod during construction of Cell 2. The certification letter is presented in Appendix H.

### 5.4.2 Field Monitoring Activities

5.4.2.1 Delivery and On-Site Storage

Upon delivery to the site, geomembrane rolls were stored in a laydown area located to the northeast of Cell 2 construction area. The rolls of geomembrane had nylon straps, which were used to lift the rolls. The rolls were transported by a front-end loader. Occasionally, the rolls were temporarily stored adjacent to the construction area prior to deployment. CQA personnel monitored the delivery, unloading, and storage procedures. The CQA personnel compared the roll numbers to the geomembrane rolls that were sampled at the manufacturer's plant and also to the bill of lading. The CQA personnel observed that procedures were used that minimized the potential for damage to the rolls.

5.4.2.2 Deployment

The geomembrane rolls were lifted using a spreader bar attached to a front-end loader. A low ground pressure rubber tracked vehicle was used in the deployment of geomembrane panels over the previously installed GCL panels using procedures approved by the Construction Manager to assure no damage to the GCL. The installer generally deployed the geomembrane panels from the top of the Cell 2/3 intercell berm northward and across the cell floor and in accordance with the approved panel layout drawing. The installer used laborers to manually position the panels.

CQA personnel monitored the deployment of each geomembrane panel or roll. During deployment, the CQA personnel checked for the following:

- manufacturing defects;
- damage that may have occurred during shipment, storage, or handling; and/or
- damage resulting from installation activities, including damage as a consequence of panel placement, seaming operations, or weather.

If the materials were observed to be damaged or deficient, the installer was notified and the damaged materials were either discarded or repaired. CQA personnel observed repair locations, either during or after the repair were complete.

Details of the geomembrane panel placement were recorded by CQA personnel on the panel placement monitoring logs that are presented in Appendix K.

5.4.2.3 Trial Seams

Prior to production seaming, the installer prepared geomembrane trial seams at the beginning of each seaming period and at least once each five hours for each piece of seaming equipment and each technician using a specific piece of seaming equipment. CQA personnel observed the trial seaming operations. The following procedure was used to evaluate the trial seams:

- trial seam samples varying in length from 3 ft to 15 ft (0.9 m to 4.5 m) and having a width of approximately 12 in. (0.3 m) wide were welded under similar conditions as for production seaming;

- test strips were cut across the trial seam at random locations using a manual dye press; each test strip was approximately 1 in. (25 mm) wide by 8 in. (200 mm) long;

- two test strips were tested in peel and two were tested in shear using a calibrated tensiometer;

- the passing criteria for the tests were as follows:

  **Fusion**

  - *Peel test* - a minimum bonded seam strength of 115 lb/in. (15 kN/m) and the observation of a Film Tearing Bond (FTB); and

  - *Shear test* - a minimum bonded seam strength of 151 lb/in. (23 kN/m); and the observation of a FTB;

**Extrusion**

- *Peel test* - a minimum bonded seam strength of 84 lb/in. (13 kN/m); and the observation of a FTB; and

- *Shear test* - a minimum bonded seam strength of 151 lb/in. (21 kN/m); and the observation of a FTB;

- if any of the strips failed, corrective actions to the welding procedure were implemented, a new trial seam was fabricated, and the test procedure repeated; passing tests in both peel and shear were achieved prior to acceptance of the trial seam; if these retest strips failed the welder and/or the equipment were rejected until the problem was corrected and two consecutive passing trial seams were completed; and

- once a trial seam passed both tests, the technician was authorized to proceed with production seaming following the procedures and controls used to prepare the accepted trial seams; occasionally, the installer's foreman authorized the technician to proceed with the field seaming operations prior to testing of the strips and if the test failed, the seamed area was capped in its entirety and the welding equipment was not used again until two passing trial seams were obtained.

A total of 267 trial seams were observed by CQA personnel during Cell 2 construction. A total of 136 trial seams were made using double-track fusion (i.e., hot wedge) welders and 131 were made using extrusion welders. A total of 25 trial seams failed (15 fusion seams and 10 extrusion seams). In the case of a failing test, the retesting protocol described above was followed.

Trial seam samples were not archived. The trial seam test results are presented in Appendix L.

5.4.2.4 Production Seams

Geomembrane production seaming operations were monitored by CQA personnel. The majority of the geomembrane production seams were fabricated using double-track fusion (i.e., hot wedge) welders. Geomembrane seam repairs were made using hand-held extrusion welders. During or after fabrication, the geomembrane seams were visually examined for workmanship and continuity. Geomembrane seaming logs are presented in Appendix M.

A cold weather seaming plan was submitted by the installer in the event ambient temperatures dropped below 40°F (5°C). However, the cold weather seaming specifications were not implemented during the Cell 2 construction season.

### 5.4.3 Nondestructive Seam Testing

#### 5.4.3.1 Scope

Nondestructive testing of geomembrane seams was periodically monitored by CQA personnel. Geomembrane seams were nondestructively tested by the installer for continuity using the air pressure or the vacuum-box test procedures. Double-track fusion seams were tested using air pressure test methods. The vacuum-box test method was used for seams made with extrusion welders. Failed air pressure test seams were capped and retested using vacuum-box test methods after minimizing the failed seam length. Leaks identified using the vacuum-box method were repaired and retested, as described in Section 5.4.5 of this report.

#### 5.4.3.2 Air Pressure Testing

Accessible double-track fusion seams were nondestructively tested using the air pressure test. The procedure used by the installer for air pressure testing was as follows:

- CQA personnel visually observed the integrity of the annulus of the section of seam being tested;
- a test section was isolated by sealing the ends of the annulus using heat and pressure;
- the needle of a pressure test apparatus was inserted into the annulus at one end of the seam;

- the annulus was inflated to a gauge pressure of approximately 25 to 30 psi (170 to 200 kPa) with an air pump;
- the gauge pressure was maintained for at least five minutes;
- if the pressure loss exceeded 3 psi (23 kPa), or if the pressure did not stabilize, the faulty area was repaired in accordance with Section 5.4.5 of this report;
- the location of the test was recorded along with the testing pressures; and
- upon completion of the test, airflow through the entire annulus was confirmed by releasing the air from the seam at the opposite end from where the needle was inserted.

Geomembrane air pressure test logs are presented in Appendix P.

5.4.3.3 Vacuum-Box Testing

The vacuum-box was used by the installer to nondestructively test extrusion seams and repairs. The procedure used by the installer for vacuum testing was as follows:

- vacuum-box assembly was connected to the vacuum pump;
- a strip of seam was wet with a soapy solution;
- the vacuum-box assembly was placed over the wetted area;
- the bleed valve was closed and the vacuum valve was opened;
- the box was forced onto the sheet until a vacuum was established as evidenced by a negative box pressure of approximately 5 psi (34 kPa);
- the seam was examined through the viewing window for a period of approximately 20 seconds for the occurrence of air bubbles;
- the location of any leaks were recorded;

- the vacuum valve was closed and the bleed valve was opened; and
- the assembly was removed and the process was continued.

On the fusion-welded seams (i.e., tie-in seams, butt seams) that were not air pressure tested, the installer trimmed the overlap and vacuum box tested the seam. When nondestructive testing indicated repairs were necessary, repairs were made in accordance with procedures presented in Section 5.4.5 of this report and the vacuum testing repeated. Vacuum test logs are presented in Appendix P.

### 5.4.4 Destructive Seam Sample Testing

#### 5.4.4.1 Scope

In accordance with the CQA Plan, CQA personnel identified and collected geomembrane seam samples for destructive testing. The samples were forwarded to GeoSyntec's MTL.

A total of 115 geomembrane seam sample locations were identified during Cell 2 construction; 45 passing and 21 failing tests on the geomembrane secondary liner and 39 passing and 10 failing tests on the geomembrane primary liner. Approximately 35,100 linear ft (10,700 linear meter) of seams were constructed. This corresponds to an approximate sample frequency of one per 450 linear feet (135 linear meter) of seam. This frequency meets the acceptable sample frequency of one per 500 linear feet (150 linear meter) required by the CQA Plan. Prior to the removal of a full seam sample, the installer took two geomembrane test strips from either end of the destructive sample. Each strip was tested in the field in peel. If the peel samples exhibited a FTB failure mode and minimum strength, the adjacent destructive seam sample was shipped to the laboratory for testing.

For a destructive seam sample to be considered as passing, the following seam strength criteria had to be met on four out of the five tests performed on each of the destructive seam specimens obtained from each of the destructive seam samples. In addition, a non-FTB was considered to exhibit more than 10 percent seam separation.

**Fusion**

- *Peel test* - a minimum bonded seam strength of 115 lb/in. (15 kN/m) and the observation of a FTB; and

- *Shear test* - a minimum bonded seam strength of 151 lb/in. (23 kN/m); and the observation of a FTB;

**Extrusion**

- *Peel test* - a minimum bonded seam strength of 84 lb/in. (13 kN/m); and the observation of a FTB; and

- *Shear test* - a minimum bonded seam strength of 151 lb/in. (21 kN/m); and the observation of a FTB;

In addition, if more than one non-FTB failure (i.e., greater than or equal to 10 percent seam separation) was observed, the destructive seam sample would fail.

5.4.4.2 Sampling Procedures

At each destructive seam sample location, a test sample that measured approximately 12 in. (300 mm) across the seam and 42 in. (1.1 m) along the seam was obtained. The sample was divided and distributed as follows:

- 12 in. (300 mm) wide by 12 in. (300 mm) long for owner's archives;

- 12 in. (300 mm) wide by 12 in. (300 mm) long for the installer; and

- 18 in. (500 mm) wide by 12 in. (300 mm) long for CQA laboratory testing.

5.4.4.3 Test Results

Off-site laboratory testing of geomembrane seam test samples was performed in accordance with the CQA Plan at the MTL. In the laboratory, 1 in. (25 mm) wide test specimens were removed from the destructive seam sample using a die press. On a gauged tensiometer, five test specimens were tested in peel for adhesion. For fusion seams, tests were performed on both the inside track and on the outside track. Additionally, five specimens were tested for shear strength. The seam-strength criteria and the acceptance/rejection criteria described in this Section were used.

For Cell 2, 29 failures were recorded on the initial destructive samples; 23 failures occurred in the field test strips and 6 failures occurred in the laboratory destructive samples. In each case, the failed area was isolated by selecting additional test-strip locations at a minimum distance of 10 ft (3 m) on either side of the failure. If the additional test strips had passing results, a full destructive seam sample was taken. These destructive seam samples were tested in accordance with procedures previously described in this section. Thirty-seven (37) additional seam samples were obtained to isolate failures and on reconstructed seams; 14 on the geomembrane primary liner and 23 on the geomembrane secondary liner. Seams having failing destructive samples were repaired using procedures presented in Section 5.4.5. The destructive seam test sample locations were also repaired using the procedure presented in Section 5.4.5. The destructive seam test results and a summary of the number of samples obtained are presented in Appendix N.

### 5.4.5 Geomembrane Repairs

The procedures presented in this subsection were used by the installer during the following repair operations:

- patching holes and tears;
- capping failed seams;
- spot-extruding impact damage or other minor scratches; and
- grinding and extrusion welding small sections of failed fusion seams (if the exposed edge was accessible).

The repair procedure for fusion seams, was to cap strip the failed seam. This procedure was used for seams with insufficient overlap and used for failing destructive tests.

In the cases where patches or caps were used to repair the damaged geomembrane (i.e., small holes, tears, or on seams which failed nondestructive or destructive tests), an approximately 12 in. (300 mm) wide capping strip was used. All panel tie-in seams (i.e., T-seams) were extrusion welded/repaired. During the repair or panel tie-in operations, the following provisions were implemented:

- technicians and seaming equipment used during repair operations had trial seams approved prior to use;
- geomembrane surfaces to be repaired were clean and dry at the time they were welded;
- patches or caps extended at least 6 in. (0.15 m) beyond the edge of the defect, and all corners were rounded;
- fusion annuli were ground down to the surface of the bottom geomembrane at the ends of the seams; and
- repairs were vacuum tested and visually observed for continuity.

Seam and panel repair locations are presented in Appendix P. Complete panel layout drawing indicating the location of seam and panel repairs are shown on the record drawings.

## 5.5 CQA of Geotextile

### 5.5.1 Conformance Testing and Documentation

Three types of geotextile were used in construction of Cell 2:

- a needle punched nonwoven geotextile having a weight per unit area of 7 $oz/yd^2$ ( 240 $g/m^2$) was used for filtration and separation applications (i.e., geotextile filter). This geotextile was manufactured by Synthetic Industries, Ringgold, Georgia.

- a needle punched nonwoven geotextile having a nominal/minimum weight per unit area of 10 $oz/yd^2$ (340 $g/m^2$) was used for cushioning applications (i.e., cushion geotextile). This geotextile was manufactured by Synthetic Industries, Ringgold, Georgia; and

- a needle punched nonwoven geotextile having a nominal weight per unit area of 16 $oz/yd^2$ (540 $g/m^2$) was used for cushioning applications (i.e., supplemental cushion geotextile). This geotextile was manufactured by Synthetic Industries, Ringgold, Georgia.

CQA personnel obtained 16 conformance samples from the 285 geotextile rolls delivered to the site. Six (6) conformance samples were obtained from 98 rolls of filter and separator geotextile, nine (9) conformance samples were obtained from 172 rolls of geotextile cushion, and one (1) conformance sample was obtained from 15 rolls of supplemental geotextile cushion. These sampling frequencies exceed the acceptable frequency of one per 100,000 $ft^2$ (9,300 $m^2$) required by the project documents. The conformance samples were forwarded to GeoSyntec's MTL for testing. The conformance test results and the manufacturer's QC certificates were reviewed by CQA personnel and were found to be in compliance with the project documents. The manufacturer's QC documentation is presented in Appendix H. GeoSyntec's conformance test results are presented in Appendix I. A summary of the properties of the geotextile material and the conformance test results are presented in Tables 5-5, 5-6, and 5-7.

### 5.5.2 *Field Monitoring Activities*

#### 5.5.2.1 Delivery and On-Site Storage

Upon delivery to site, geotextile rolls were stored on dunnage in an area located northeast of the Cell 2 construction area. The geotextile rolls had a plastic wrapping to protect against ultraviolet radiation, dust, and dirt. The geotextile rolls were transported by a front-end loader. The rolls were deployed or temporarily stored on dunnage adjacent to the construction area prior to deployment. CQA personnel periodically monitored the delivery, unloading, and storage procedures. The CQA personnel observed that the material was handled in an appropriate manner.

5.5.2.2 Deployment

CQA personnel monitored the deployment of the geotextile rolls for the following:

- manufacturing defects;
- damage that may have occurred during shipment, storage, and handling; and
- damage resulting from installation activities.

If any materials were observed to be damaged, the installer was notified and the damaged materials were either discarded or repaired. CQA personnel observed repair locations, either during or after the repair was complete.

CQA personnel monitored the deployment of the geotextile as well as its condition after installation, to verify that the installer:

- unrolled the geotextile down the slope in a manner which kept the geotextile panel in sufficient tension to avoid excessive wrinkling and folding; and
- took measures to avoid the entrapment of dust, stones, and other objects in the geotextile.

After deployment of the geotextile, CQA personnel observed that the following procedures were used by the installer to join adjacent rolls of geotextile:

- geotextile panels were overlapped a minimum of 6 in. (0.15 m); and
- geotextile panels were continuously sewn.

The installer used a 2200 Union Special sewing machine. The seams were sewn with a single-thread chain stitch using a nylon bonded thread, supplied by GSE Lining Technology, Inc., Houston, Texas.

The installer repaired holes or tears in the geotextile by placing a patch of the same material over the hole or tear with at least 2 ft (0.6 m) beyond the edges of the hole or tear and thermally bonded with a lyster or overlapped 6 in. and sewn.

## 5.6 CQA of Liner Penetration Boxes

Cell 2 liner penetration boxes were manufactured by Plastik Werks, Gainesville, Georgia. GeoSyntec reviewed shop drawings and fabrication procedures prior to production. Liner penetration boxes were air pressure tested in the factory and in the field, as required, filled with bentonite, and sealed. Pressure test logs for the liner penetration boxes are presented in Appendix Q. Geomembrane connections to the liner penetration boxes were nondestructively tested using vacuum-box testing as outlined in Section 5.4.3.3. CQA personnel monitored installation and testing activities.

## 5.7 CQA of HDPE Piping

CQA personnel monitored the installation of the various HDPE piping components of the leachate collection and leak detection systems. Installation activities that were monitored by GeoSyntec's CQA personnel included the following:

- 6 in. (150-m) diameter HDPE SDR-11 perforated-wall gravity line located within the LDS and LCS drainage corridor;

- leak detection system (LDS) gravity pipeline, consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in. (250 mm) diameter HDPE SDR-11 solid-wall containment pipe, which transitions within an LDS manhole to a 3 in. (75 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 8 in. (200 mm) diameter HDPE SDR-11 solid-wall containment pipe and ultimately connects within a leachate conveyance system (LCS) manhole to a main LCS pipe;

- redundant leachate collection system (LCS) gravity pipeline, consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in. (250 mm) diameter HDPE SDR-11 solid-wall containment pipe, and ultimately connects within an LCS manhole to a main LCS pipe;

- leachate collection system (LCS) gravity pipeline, consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in. (250-m) diameter HDPE SDR-11 solid-wall containment pipe, and ultimately connects within an LCS manhole to a main LCS pipe consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in.(250 mm) diameter HDPE SDR-11 solid-wall containment pipe.

### 5.7.1 Pipe Conformance Testing and Documentation

The pipe for the leachate collection system was delivered to the site during Cell 2 construction. Phillips Driscopipe of Hagerstown, Maryland supplied the pipe. The pipe manufacturer provided the QC certifications for each lot of pipe supplied. CQA personnel reviewed this documentation and verified that the pipe's property data were in compliance with the requirements of the project documents. CQA personnel also verified the proper size and spacing of the perforations by visual observation of the pipe while in the stockpile or during installation. No conformance testing of the pipe was required by the CQA Plan.

### 5.7.2 Field Monitoring Activities

#### 5.7.2.1 Delivery and Placement

The pipe was shipped from the manufacturer on wooden pallets. Upon delivery to the site, pipe was stockpiled in an area located northeast of the Cell 2 construction area. The pipe was transported from the stockpile to the construction area by a track hoe or a front-end loader using nylon straps. The pipe was deployed or temporarily stored adjacent to the construction area.

The 40 ft (12-m) long sections were joined using butt-fusion welding techniques and electrofusion couplings. The CQA activities associated with each of the pipe joining techniques are described below.

CQA personnel monitored the HDPE pipe butt-fusion welding procedures to ensure the following:

- the ends of the pipes to be joined were cleaned and the pipe sections were aligned;
- the welder tightly secured the pipe section in the welding unit clamps to allow the ends of the pipes to be trimmed with the facing tool immediately prior to the application of the heat disk;
- the ends of the pipe sections were heated for approximately one minute using a 450 to 500°F (232 to 260°C) heating disk;
- the welder quickly removed the heating disk and joined the pipes with pressure to create a roll-back bead; and
- after the butt-fusion weld was allowed to cool, the joined pipes were released from the welding unit.

CQA personnel monitored the electrofusion welding procedures to ensure the following:

- the ends of the pipes were cut square and even;
- the ends of the pipes to be joined were cleaned and surface prepared inside and out;
- the leads from the electrofusion coupling were secured to the processing unit supplied by the manufacturer;
- the processing unit was activated to produce a voltage range across the electrofusion coupling which induced melting; and then performed a unit test to evaluate the coupled joint; and
- the electrofusion weld was allowed to cool in accordance with manufacturer's recommendations.

Within the Cell 2 area, the piping system was constructed to allow drainage toward the liner penetration, located at the west end of the cell. During installation, perforated pipes were installed as part of the LDS, LCS and LCS Redundent leachate conveyance system. The pipe had 3 rows of 5/8 in. (16 mm) diameter holes on 6 in. (150 mm) centers along the length. Each row was staggered 2 in. (50 mm). LDS and LCS drainage corridor material (i.e., No. 78 and No. 57 stone, respectively) was placed around the pipe. Both the pipe and aggregate were installed over a supplemental 16 $oz/yd^2$ (540 $g/m^2$) nonwoven geotextile.

The following approximate lengths of pipe were installed in the Cell 2 area:

- 660-ft (201-m) of 6-in (150 mm) diameter HDPE LDS pipe; and
- 660-ft (201-m) of 6-in (150 mm) diameter HDPE LCS pipe.

The HDPE piping within Cell 2 was connected to the liner penetration boxes described in Section 5.6. The liner penetration boxes were the only points of penetration through the geomembrane liners. The leachate will be discharged through the liner penetration boxes within Cell 2 via gravity pipeline to the leachate conveyance system. The leachate conveyance system is comprised of an LDS and LCS manhole and transmission pipe that conveys leachate to the permanent lift station. The permanent lift station will pump leachate via a forcemain within a containment pipe to the BioSurge Lagoon. The leachate conveyance system is described in Section 6.0.

5.7.2.2 Video Taping

Following completion of construction activities, including placement of the protective layer, the contractor completed video taping of the LCS, LDS, and LCS redundent piping from the LCS/LDS manholes to a minimum of 100 ft into the cell for each piping system. CQA personnel monitored the video taping.

# TABLE 5-3

## 80-MIL THICK HDPE GEOMEMBRANE (TEXTURED) PROPERTIES SUMMARY
## CELL 2

| DESCRIPTION | TEST STANDARD | MANUFACTURER[3] SPECIFICATIONS (MARV)[7] | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($ft^2$) | | NUMBER OF TESTS[2] | | | | RANGE OF QA TEST RESULTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | REQUIRED | | PASSING | | | |
| | | | | Manf. QC | Conf. QA[4] | Manf. QC | Conf. QA | Manf. QC | Conf. QA | MAXIMUM | MINIMUM |
| Yield Strength (lb/in.) | ASTM D 638[5] | 173 | ≥168 [6] | 40,000 | 100,000 | 21 | 9 | 98 | 11 | 219 | 197 |
| Elongation at Yield (%) | ASTM D 638[5] | 13 | ≥12 | 40,000 | 100,000 | 21 | 9 | 98 | 11 | 22 | 19 |
| Break Strength (lb/in.) | ASTM D 638[5] | 324 | ≥120 [6] | 40,000 | 100,000 | 21 | 9 | 98 | 11 | 436 | 396 |
| Elongation at Break (%) | ASTM D 638[5] | 560 | ≥100 | 40,000 | 100,000 | 21 | 9 | 98 | 11 | 1285 | 608 |
| Thickness (mil) | ASTM D 5994 | 80 nominal<br>76 min. | Avg. 80<br>Min. 76 | 40,000 | 100,000 | 21 | 9 | 98 | 11 | 84 | 82 |
| Specific Gravity (NA) | ASTM D 792 or ASTM D 1505 | 0.940 | ≥0.935 (resin)<br>≥0.94 (sheet) | 40,000[4] | 100,000 | 21 | 9 | 98 | 11 | .947 | .946 |
| Tear Resistance (lb) | ASTM D 1004 Die C Puncture | 60 | ≥56 | 40,000 | NA | 21 | NA | 98 | NA | NA | NA |
| Carbon Black Content (%) | ASTM D 1603 | 2.0 | 2-3 | 40,000 | 100,000 | 21 | 9 | 98 | 11 | 2.6 | 2.2 |
| Carbon Black Dispersion | ASTM D 5596 | Category 1 or 2 | Category 1 or 2 | 40,000 | 100,000 | 21 | 9 | 98 | 11 | CAT. 1 | CAT. 2 |
| Low Temperature Brittleness (°C) | ASTM D 746B | -75 | -60 max. | 400,000 | NA | 2 | NA | 4 | NA | NA | NA |
| Dimensional Stability (%) (@ 212°F, 15 min.) | ASTM D 1204 | ±2 max. | ±2 max. | 400,000 | NA | 2 | NA | 98 | NA | NA | NA |
| ESCR (hr)[6] | ASTM D 5397 | 500 | ≥500 | 400,000 | NA | 2 | NA | 3 | NA | NA | NA |
| | | | | | | | | | | | |

Total Number of Rolls Delivered to Site: 98 (840,096 $ft^2$) Total Number of Conformance Samples: 11

Notes:
(1) Reference Section 02770 of the Specifications and Section 7 of the CQA Plan for further details.
(2) The approximate number of tests required is based on total of 840,096 $ft^2$ for the Cell 2 installation.
(3) GSE Lining Technologies, Houston, Texas is the geomembrane supplier. Roll dimensions are 24 ft. x 357 ft. (avg. Length)
(4) Tests performed at a frequency of one per lot or at listed frequency, whichever is greater. A lot is as defined by ASTM 4354. Minimum test frequency of resin is 1 test per railcar.
(5) ASTM D 638 is modified by NSF-54 Annex A.
(6) Time-to-failure at a tensile stress of 30% of the tensile yield strength
(7) MARV = (minimum average roll value), 95 percent lower confidence limit.

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# TABLE 5-4

## 80-Mil Thick HDPE GEOMEMBRANE (PRIMARY/SECONDARY) (TEXTURED)
## SEAM PROPERTIES SUMMARY
## CELL 2

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | | REQUIREMENTS | APPROXIMATE NUMBER OF TESTS REQUIRED |
|---|---|---|---|---|---|
| | | Fusion | Extrusion | | |
| Panel Deployment | - | - | - | Ambient placement temperature are between 40°F and 104°F. | Assumption used for destructive seam testing is that each roll is approximately 24 ft by 357 ft (avg.) |
| Trial Seams: (peel) | ASTM D 4437 | FTB<br>115 ppi | FTB<br>84 ppi | Prior to seaming period every 5 hours, or if seaming apparatus is turned off. | Minimum of:<br>2 no. peel per trial seam<br>2 no. shear per trial seam |
| (shear) | ASTM D 4437 | FTB<br>151 ppi | FTB<br>151 ppi | | |

Notes: (1) One failure requires two consecutive successful trial seams.

| DESCRIPTION | TEST STANDARD | PROJECT[1][2][3] SPECS | | TEST FREQUENCY | APPROXIMATE NUMBER OF TESTS REQUIRED | ORIGINAL NO. OF SAMPLES | NUMBER OF FAILURES | | ADDITIONAL NUMBER OF SAMPLES TO ISOLATE FAILURES | TOTAL NUMBER OF SAMPLES |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Fusion | Extrusion | | | | FIELD | LAB | | |
| Seam Strength[1]:<br>Production Welds<br>and<br>Reconstructed Seams | ASTM D 4437<br><br>ASTM D 4437 | FTB<br>115 ppi<br><br>FTB<br>151 ppi | FTB<br>84 ppi<br><br>FTB<br>151 ppi | 500 lin. ft | secondary<br>min. of<br>39<br>primary<br>min. of<br>32 | secondary<br>min. of<br>43<br>primary<br>min. of<br>35 | secondary<br>17<br>primary<br>8 | secondary<br>4<br>primary<br>2 | secondary<br>23<br>primary<br>14 | secondary<br>66<br>primary<br>49 |

Note: (1) Reference Section 02770 of the Specifications and Section 7 of the CQA Plan for further details.
(2) 1 in. wide test strips are tested at a strain rate of 2 in. per minute. One non-FTB per five specimens is acceptable provided that the strength requirements are met.
(3) FTB = Film Tear Bond (maximum 10 percent seam separation)

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# TABLE 5-5

## NONWOVEN GEOTEXTILE (7 oz/yd$^2$) FILTER PROPERTIES SUMMARY
## CELL 2

| DESCRIPTION | TEST STANDARD | MANUFACTURER SPECIFICATIONS (MARV)[4] | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY | | NUMBER OF TESTS[2] | | | | RANGE OF QA TEST RESULTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | REQUIRED | | PASSING | | | |
| | | | | Manf. QC | Conf. QA | Manf. QC | Conf. QA | Manf. QC | Conf. QA | MAXIMUM | MINIMUM |
| Mass Per Unit Area (oz/yd$^2$) | ASTM D 5261 | 7 | ≥7 | 50,000 | 100,000 | 9 | 5 | 9 | 6 | 9.0 | 8.0 |
| Mullen Burst Strength (psi) | ASTM D 3786 | 400 | ≥350 | 50,000 | 100,000 | 9 | 5 | 9 | 6 | 496 | 431 |
| Grab Strength (lb) | ASTM D 4632 | 200 | ≥180 | 50,000 | 100,000 | 9 | 5 | 9 | 6 | 305 | 250 |
| Trapezoidal Tear Strength Tear (lb) | ASTM D 4533 | 85 | ≥75 | 50,000 | 100,000 | 9 | 5 | 9 | 6 | 166 | 105 |
| Puncture Strength Resistance (lb) | ASTM D 4833 | 130 | ≥75 | 50,000 | 100,000 | 9 | 5 | 9 | 6 | 164 | 144 |
| Apparent Opening Size (mm) (A.O.S.) | ASTM D 4751 | 0.180 | ≤0.212 | 100,000 | 100,000 | 5 | 5 | 9 | 6 | .15 | .13 |
| Permittivity (sec$^{-1}$) | ASTM D 4491 | 1.50 | ≥0.5 | 100,000 | 100,000 | 5 | 5 | 9 | 6 | 2.16 | 1.65 |
| Ultraviolet Resistance (%) | ASTM D 4355 | 70 | ≥70 | Cert. Ltr. | NA | NA | NA | NA | NA | NA | NA |
| Nonwoven Needle punched Polymer Composition (%) | — | 95% polypropylene | 95 polypropylene or polyester by weight | Cert. Ltr. | NA | NA | NA | NA | NA | NA | NA |

Total Number of Rolls Delivered to Site: 98

Total Number of Conformance Samples: 6

Notes:
(1) Reference Section 02714 of the Specifications and Section 9 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total of 441,000 ft$^2$ available for the Cell 2 installation.
(3) Roll dimensions are 15 ft by 300 ft for 7 oz/yd$^3$ geotextile manufactured by Synthetic Industries, Ringgold, Georgia.
(4) MARV = (minimum average roll value), 95 percent lower confidence limit.

# TABLE 5-6

## NONWOVEN GEOTEXTILE (10 oz/yd$^2$) LINER SYSTEM CUSHION PROPERTIES SUMMARY CELL 2

| DESCRIPTION | TEST STANDARD | MANUFACTURER SPECIFICATIONS (MARV)[4] | PROJECT(1) SPECIFICATIONS | TEST FREQUENCY | | NUMBER OF TESTS[2] | | | | RANGE OF TEST RESULTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | REQUIRED | | PASSING | | | |
| | | | | Manf. QC | Conf. QA | Manf. QC | Conf. QA | Manf. QC | Conf. QA | MAXIMUM | MINIMUM |
| Mass Per Unit Area (oz/yd$^2$) | ASTM D 5261 | 10 | ≥10 | 50,000 | 100,000 | 16 | 8 | 16 | 9 | 11.2 | 10.2 |
| Mullen Burst Strength (psi) | ASTM D 3786 | 510 | ≥450 | 50,000 | 100,000 | 16 | 8 | 16 | 9 | 617 | 531 |
| Grab Strength (lb) | ASTM D 4632 | 250 | ≥225 | 50,000 | 100,000 | 16 | 8 | 16 | 9 | 420 | 288 |
| Trapezoidal Tear Strength Tear (lb) | ASTM D 4833 | 100 | ≥90 | 50,000 | 100,000 | 16 | 8 | 16 | 9 | 200 | 126 |
| Puncture Strength Resistance (lb) | ASTM D 4833 | 160 | ≥120 | 50,000 | 100,000 | 16 | 8 | 16 | 9 | 204 | 178 |
| Ultraviolet Resistance (%) | ASTM D 4355 | 70 | ≥70 | Cert. Ltr. | NA | NA | NA | NA | NA | NA | NA |
| Nonwoven Needle punched Polymer Composition (%) | — | 90% polypropylene | 95 polypropylene or polyester by weight | Cert. Ltr. | NA | NA | NA | NA | NA | NA | NA |

Total Number of Rolls Delivered to Site: 172

Total Number of Conformance Samples: 9

Notes:
(1) Reference Section 02714 of the Specifications and Section 9 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total of 774,000 ft$^2$ for the Cell 2 installation.
(3) Roll dimensions are 15 ft by 300 ft for 10 oz/yd$^3$ geotextile manufactured by Synthetic Industries, Ringgold, Georgia.
(4) MARV = (minimum average roll value), 95 percent lower confidence limit.

# TABLE 5-7

## NONWOVEN GEOTEXTILE (16 oz/yd$^2$) SUPPLEMENTAL CUSHION PROPERTIES SUMMARY CELL 2

| DESCRIPTION | TEST STANDARD | MANUFACTURER SPECIFICATIONS (MARV)[4] | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY | | NUMBER OF TESTS[2] REQUIRED | | NUMBER OF TESTS[2] PASSING | | RANGE OF TEST RESULTS | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Manf. QC | Conf. QA | Manf. QC | Conf. QA | Manf. QC | Conf. QA | MAXIMUM | MINIMUM |
| Mass Per Unit Area (oz/yd$^2$) | ASTM D 5261 | 16 | ≥16 | 50,000 | 100,000 | 2 | 1 | 2 | 1 | 16.9 | 16.9 |
| Mullen Burst Strength (psi) | ASTM D 3786 | 800 | ≥700 | 50,000 | 100,000 | 2 | 1 | 2 | 1 | 918 | 918 |
| Grab Strength (lb) | ASTM D 4632 | 380 | ≥350 | 50,000 | 100,000 | 2 | 1 | 2 | 1 | 660 | 455 |
| Trapezoidal Tear Strength Tear (lb) | ASTM D 4533 | 145 | ≥120 | 50,000 | 100,000 | 2 | 1 | 2 | 1 | 306 | 189 |
| Puncture Strength Resistance (lb) | ASTM D 4833 | 240 | ≥180 | 50,000 | 100,000 | 2 | 1 | 2 | 1 | 303 | 303 |
| Ultraviolet Resistance (%) | ASTM D 4355 | 70 | ≥70 | Cert. Ltr. | NA | NA | NA | NA | NA | NA | NA |
| Nonwoven Needle punched Polymer Composition (%) | NA | 95% polypropylene | 95 polypropylene or polyester by weight | Cert. Ltr. | NA | NA | NA | NA | NA | NA | NA |

Total Number of Rolls Delivered to Site: 15

Total Number of Conformance Samples: 1

Notes:
(1) Reference Section 02714 of the Specifications and Section 9 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total of 67,500 ft$^2$ available for the Cell 2 installation.
(3) Roll dimensions are 15 ft by 300 ft for 16 oz/yd$^3$ geotextile manufactured by Synthetic Industries, Ringgold, Georgia.
(4) MARV = (minimum average roll value), 95 percent lower confidence limit.

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# 6 CONSTRUCTION QUALITY ASSURANCE – PHASE I CONSTRUCTION COMPLETION AND LEACHATE CONVEYANCE SYSTEM REPAIR

## 6.1 General

The Phase 1 completion work items performed by Petro Environmental Technologies Inc. in 1998 and monitored by GeoSyntec CQA personnel consisted of the following:

- completing road construction for the access corridor and impacted material haul road consisting of placing and compacting aggregate base material;
- installing the LCS and LDS leachate conveyance piping from the Cell 2 and Cell 3 manholes to inside the slope of each cell including pipe fittings and pressure testing;
- installing the OSDF equipment wash facility;
- completing the Cell 1 clay wedge (discussed in section 4.5.3); and
- seeding of the Phase 1 soil and soil slope areas.

The Leachate Conveyance System repair work performed by Village Building Services in 1998 and monitored by GeoSyntec CQA personnel consisted of the following:

- removing portions of the Cell 2 and Cell 3 manhole concrete cover slabs;
- excavating soil around the LDS piping, LCS and LCS Redundant piping and their cleanouts;
- repairing LDS and LCS HDPE containment and carrier piping leaks identified during 1997 pressure testing;

- pressure testing Cell 2 and Cell 3 piping after repair;
- backfilling pipe and excavations with embedment fill and compacted fill; and
- re-installing the manhole concrete cover slabs.

## 6.2 Changes in Drawings and Specifications

RCIs and DCNs were processed and approved according to procedures described in FEMP document ED-12-5002 entitled "Engineering Design Change Process." Copies of the DCNs not provided in the 1997 Final Phase I Certification Report are presented in Appendix S. There were no RCIs.

## 6.3 Pipe Conformance Testing and Documentation

The pipe for the leachate collection system 1998 installation and repair was supplied by Phillips Driscopipe of Hagerstown, Maryland. The pipe electrofusion couplings were manufactured by Central Plastics Company of Shawnee, Okahoma. The pipe manufacturer provided the QC certifications for each lot of pipe supplied. The manufacturer's QC certificates are presented in Appendix H. CQA personnel reviewed this documentation and verified that the pipe was in compliance with the requirements of the CQA Documents.

The repair of the leachate conveyance piping by Village Building Services did not involve installation of new lengths of pipe. New electrofusion couplings were used for the 6 in. gravity carrier pipe and electrofusion couplings or welded sleeves for the 10 in. containment pipe.

## 6.4 Field Monitoring Activities

CQA personnel periodically monitored the HDPE pipe (solid and perforated) butt-fusion welding procedures to verify the following:

- trial butt fusion joints were made to verify conditions were adequate at the beginning of each day for each fusion apparatus used that day; trial joining was made under the same conditions as the actual joining;

- the ends of the pipes to be joined were cleaned and the pipe sections were placed in a portable welding unit;

- the welder tightly secured the pipe section in the welding unit clamps to allow the ends of the pipes to be trimmed with the facing tool immediately prior to the application of the heat disk;

- the ends of the pipe sections were heated for approximately one minute using a 450 to 500°F (232 to 260°C) heating disk;

- the welder quickly removed the heating disk and joined the pipes with pressure to create a roll back bead;

- the butt-fusion weld was allowed to cool prior to the joined pipes being released from the welding unit; and

- all of the above was performed in general accordance with pipe and welding unit manufacturer's procedures.

CQA personnel monitored the electrofusion welding procedures to verify the following:

- the ends of the pipes were cut square and even;

- the ends of the pipes to be joined were cleaned and surface prepared inside and out;

- the leads from the electrofusion coupling were secured to the processing unit supplied by the manufacturer;

- the processing unit was activated to produce a voltage range across the electrofusion coupling which induced melting; and then performed a unit test to evaluate the coupled joint; and

- the electrofusion weld was allowed to cool in accordance with manufacturer's recommendations.

CQA personnel monitored the extrusion welding of the containment pipe sleeves to verify that:

- proper pipe cleaning and surface preparation took place;

- proper extrusion gun and welding rod was used; and

- a satisfactory continuous weld was performed.

For the leachate conveyance system pipe repair the pipes were bedded and covered with one lift of pipe embedment fill and then backfilled with compacted fill. The backfill was placed in approximately 8 in (200 mm) thick loose lifts. Hand-operated compaction equipment was used to achieve compaction of the embedment fill and compacted fill materials.

For the Phase I piping installed through the Cell 2 and Cell 3 west perimeter berms the pipes were bedded and covered with embedment sand and backfilled with compacted cohesive fill. Bentonite plugs were installed per the construction drawings. Compacted fill lifts were placed in approximately 8 in (200 mm) loose lift thickness and compacted with the Caterpillar 815 padfoot compactor after sufficient cover over the piping was obtained. CQA personnel monitored the pipe installation and backfilling of the excavations through the perimeter berms. Details of the testing are discussed in the following section.

### 6.4.1 Testing Activities

As part of the CQA activities, tests were performed on the different components of the Phase 1 construction completion work and the leachate conveyance system piping repair. The following tests were conducted or monitored by CQA personnel for the compacted fill, embedment fill, road aggregate base materials, or piping systems:

- In-place nuclear moisture/density tests were conducted on the Cell 2/3 west perimeter berm compacted fill and the LCS repair excavation backfilling.

- Grain-size distribution tests were performed on samples of compacted fill, embedment fill and aggregate base materials according to ASTM D 422 or ASTM C 136.

- Pressure tests were conducted by the contractor on the carrier and containment pipes of the LDS, LCS and LCS Redundant pipes leading to Cell 2 and Cell 3. These tests were monitored by GeoSyntec's CQA personnel.

- Concrete slump tests were performed on the concrete loads delivered to the site for the manhole cover slab repair. Concrete test cylinders were tested by an off-site laboratory (Fuller, Mossbarger, Scott and May Engineers, Inc.). The concrete cylinder test results were reviewed by the CQA personnel to ensure conformance to the project documents.

Test data documentation for the compacted fill placed for the Phase 1 completion construction is included in Appendix G with the Cell 2 field and labortory test results. Test results for the leachate conveyance system repair are provided in Appendix Q. Summaries of the repair area compacted fill, field and laboratory testing and the pipe embedment fill testing are given in Table 6-1 and Table 6-2, respectively.

CQA personnel monitored the installation of the geosynthetics, drainage material and sump construction for the OSDF equipment wash facility. The geosynthetics monitoring and documentation included:

- trial seams and production seaming included fusion and extrusion welding;
- repairs and nondestructive testing;
- preparation of panel placement sketches;
- location of CQA testing of destructive samples; and
- installation of HDPE collection sump.

For the OSDF equipment wash facility CQA monitored trial seaming (15 trial seams), non-destructive testing and the sampling of 1 destructive sample. CQA also sampled and tested 1 sample of granular drainage material (No. 57 stone). Test and documentation data are provided in Appendix Q.

CQC personnel monitored the completion construction of the placement and compaction of the base stone material (No. 304 stone) for the access corridor road, access corridor turn-around and impacted material haul road adjacient to the OSDF. Final placement, grading and compaction of the road surface with a D6 dozer and smooth drum vibratory roller was observed by CQA personnel. The impacted material haul road also received substantial compaction from the loaded haul trucks during the 1998 construction. Details and results of the road density testing are presented in NCR No. 1702-011, provided in Appendix U. This NCR provides documentation that acceptable density was achieved. Table 6-3 provides a summary of the labortory and field testing.

CQA personnel also monitored the 1998 pressure testing for piping and liner penetration boxes performed by the Leachate Conveyance System contractor and/or the Phase I/II contractor. The pressure was monitored by CQA personnel for a minimum period of 1 hour during which time the pressure in the pipe was recorded. Results were reviewed by the Resident Engineer. The pressure test documentation is provided in Appendix Q.

# TABLE 6-1

## 1998 LEACHATE CONVEYANCE SYSTEM REPAIR COMPACTED FILL MATERIAL PROPERTIES SUMMARY

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED[2] | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size:<br>Sieve | ASTM D 422 | 100%<br>Finer than 3.0 inch | 1 per 1,500 | 1 | 2 |
| Compaction | ASTM D 698 | — | 1 per 1,500/<br>as required | 1 | 2 |
| Moisture | ASTM D 2216<br>ASTM D 4643 | — | 1 per 1,500/<br>as required | 1 | 2 |
| Soil Classification | ASTM D 2487 | GC, SC, SM, ML or CL | 1 per 1,500 | 1 | 2 |
| Atterberg Limits | ASTM D 4318 | — | 1 per 1,500 | 1 | 2 |
| FIELD TEST | | | | | |
| Sand Cone:<br>Soil density<br>Soil moisture | <br>ASTM D 1556<br>ASTM D 2216 | <br>—<br>— | 1 per 25<br>passing Nuclear<br>tests | 1 | 2 |
| Nuclear Gauge:<br>Soil density<br>Soil moisture | <br>ASTM D 2922<br>ASTM D 3017 | <br>95%<br>± 3% O.M.C. | 1/250 L.F./lift | 10 | 24<br>(1) |

NOTES: (1) Reference Section 02200 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total volume of 450 $yd^3$ for the Phase I construction.

## TABLE 6-2

## 1998 PHASE 1 COMPLETION CONSTRUCTION EMBEDMENT FILL

| DESCRIPTION | TEST STANDARD | PROJECT[1] SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED[2] | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size: Sieve | ASTM C 136 | Section 703.06 Ohio DOT | 1 per 1,000 | 1 | 2 |
| Soil Classification | ASTM D 2487 | GW, GP, SW or SP | 1 per 1,000 | 1 | 2 |
| FIELD TEST | | | | | |
| Depth Verification: Survey | Visual | 6 in. thick (compacted)[3] | — | — | — |

NOTES: (1) Reference Section 02215 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total volume < 100 $yd^3$ for the Phase I construction.
(3) Compacted using four passes with vibratory plate compaction.

# TABLE 6-3

## 1998 PHASE I COMPLETION CONSTRUCTION ACCESS CORRIDOR AND IMPACTED MATERIAL HAUL ROAD AGGREGATE BASE

| DESCRIPTION | TEST STANDARD | PROJECT(1) SPECIFICATIONS | TEST FREQUENCY ($yd^3$) | APPROXIMATE NUMBER OF TESTS REQUIRED(2) | NUMBER OF TEST PERFORMED (FAILURES) |
|---|---|---|---|---|---|
| LABORATORY TEST | | | | | |
| Particle Size: Sieve | ASTM C 136 | Item 304 Ohio DOT | 1 per 1,000 | 2 | 2 |
| Compaction | ASTM D 698 | - | - | - | 1 |
| Soil Classification | ASTM D 2487 | — | — | — | 2 |
| FIELD TEST | | | | | |
| Nuclear Gauge<br>Soil Density<br>Soil Moisture | ASTM D 2922<br>ADTM 3017 | $\geq$98 % of Test Density (3) | 1 per 100 lineal ft per lift | 23 | 32<br>(7) |
| Depth Verification: Survey | Visual | 6 in. thick (compacted) | — | — | — |

NOTES: (1) Reference Section 02230 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a total volume of less than 1000 $yd^3$ for 1998 Phase I construction.

(3) Use of ASTM D698 Maximum Density for test density is discussed in NCR 1702-011 provided in Appendix U.

# 7 SUMMARY AND CONCLUSIONS

Construction of the OSDF Cell 2 project and the completion of the remaining items of the Phase I and Leachate Conveyance System projects for the FEMP was performed during the period from January 1998 to December 1998. During this time, GeoSyntec provided from one to nine on-site CQA personnel to monitor the construction of these projects. As part of their CQA activities, CQA personnel monitored the construction and installation of the following components:

- earthwork (subgrade preparation, perimeter and intercell berm construction, compacted clay liner, LDS and LCS drainage layer construction, and protective layer);
- geosynthetics (installation of GCL, geomembrane primary and secondary liners, and geotextile layers for Cell 2);
- stormwater management facilities; access corridor; impacted material haul road adjacent to the OSDF; equipment wash facility; and borrow area construction; and
- leachate conveyance system construction and repair (installation of horizontal monitoring wells, LDS, LCS and LCS Redundant collection pipes, LDS and LCS gravity pipes to the manholes, and liner penetration boxes).

During construction of the above components, CQA personnel verified that conformance and CQA testing were performed on the construction materials at the frequencies required in the project documents, and that materials meeting the project document requirements were used. CQA personnel also verified that conditions or materials identified as not conforming to the project documents were replaced, repaired, and/or retested, or that clarifications to the project documents were approved by the designer, GeoSyntec, to allow the conditions or materials to be used, as described in this report.

The results of the CQA activities undertaken by GeoSyntec indicate that Cell 2 liner system construction and Phase I and Leachate Conveyance System completion construction were performed in accordance with the Specifications, Construction Drawings and Support Plans, prepared by GeoSyntec Consultants, Atlanta, Georgia, and approved by OEPA and USEPA.

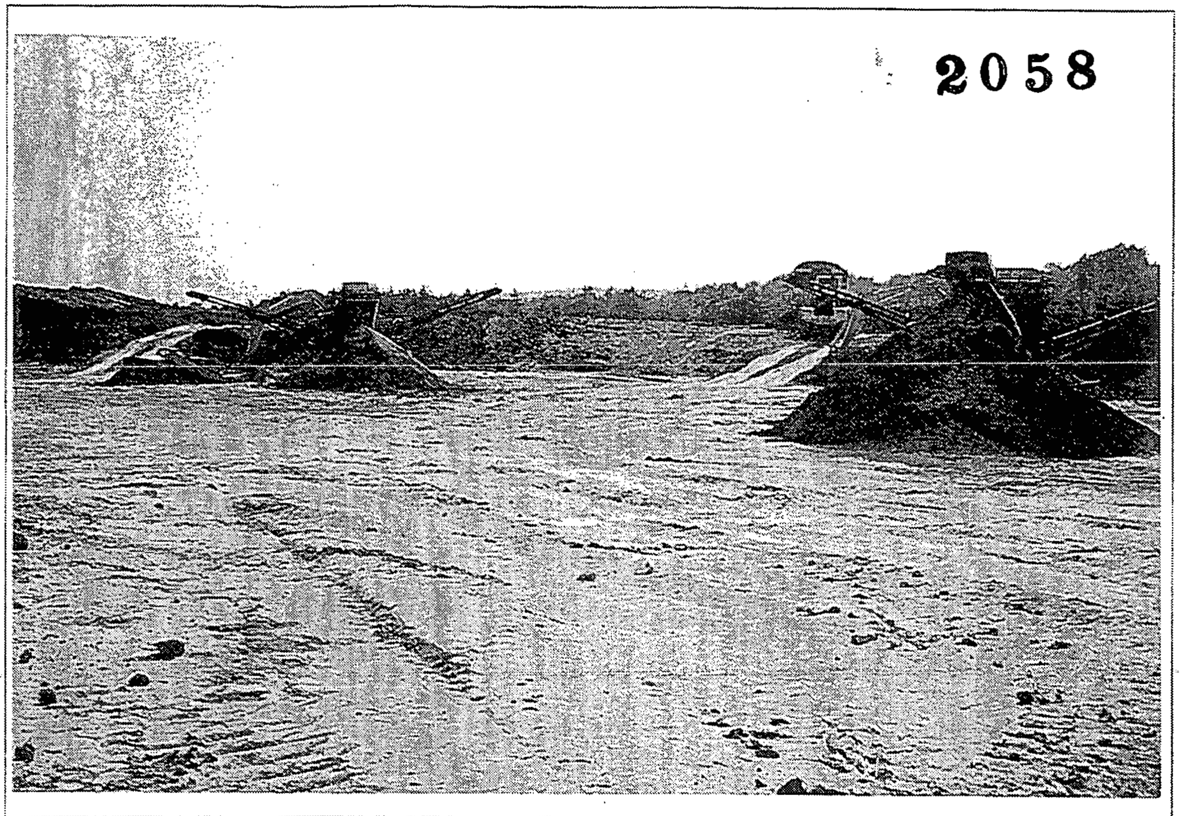
STATE OF OHIO
DANIEL G.
BODINE
E-61363
REGISTERED
PROFESSIONAL ENGINEER

Daniel G. Bodine

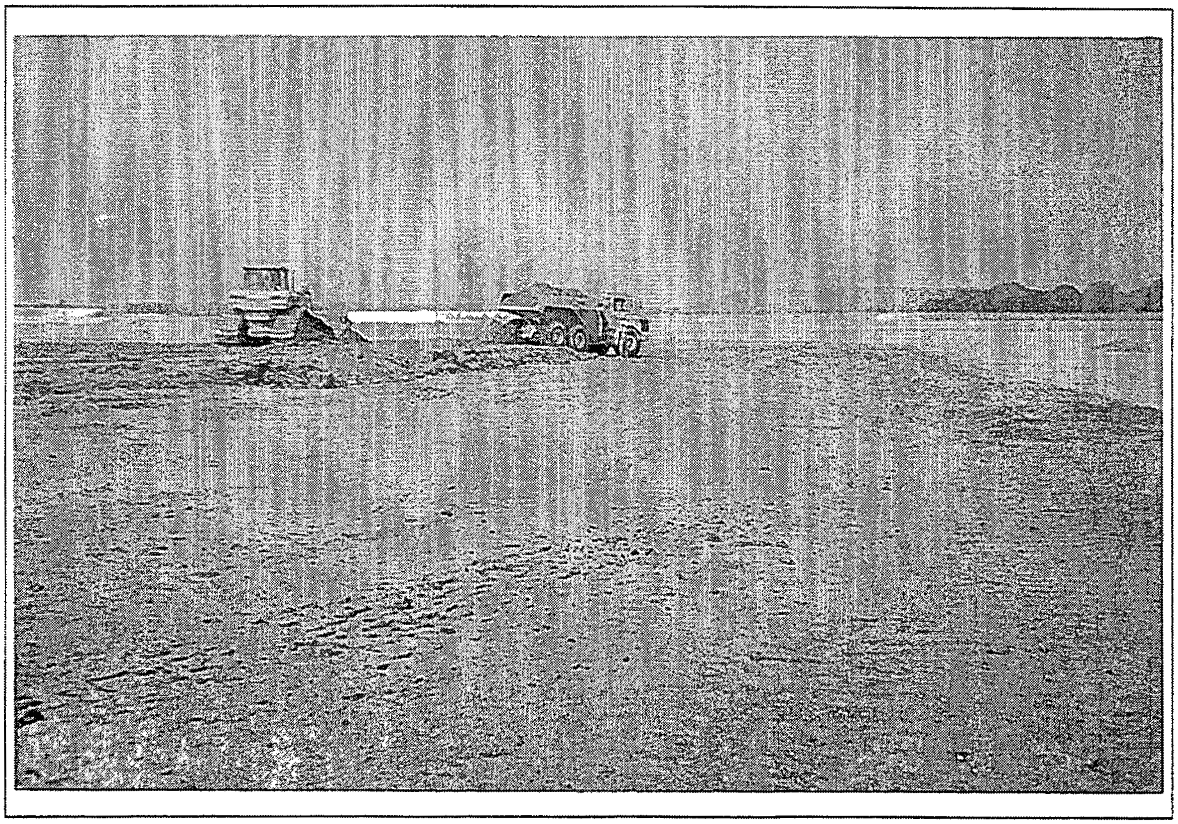
Daniel G. Bodine, P.E.
Project Manager
Ohio P.E. No. 61363

# APPENDIX A:

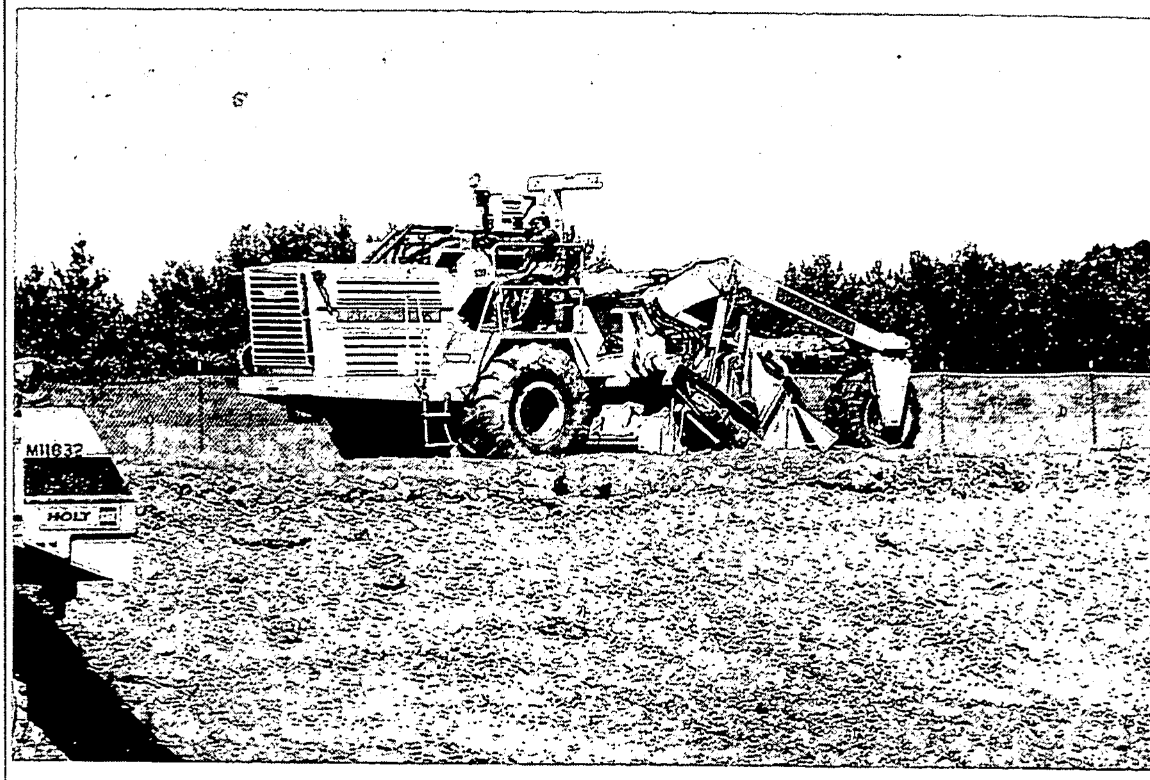
# PHOTOGRAPHIC DOCUMENTATION



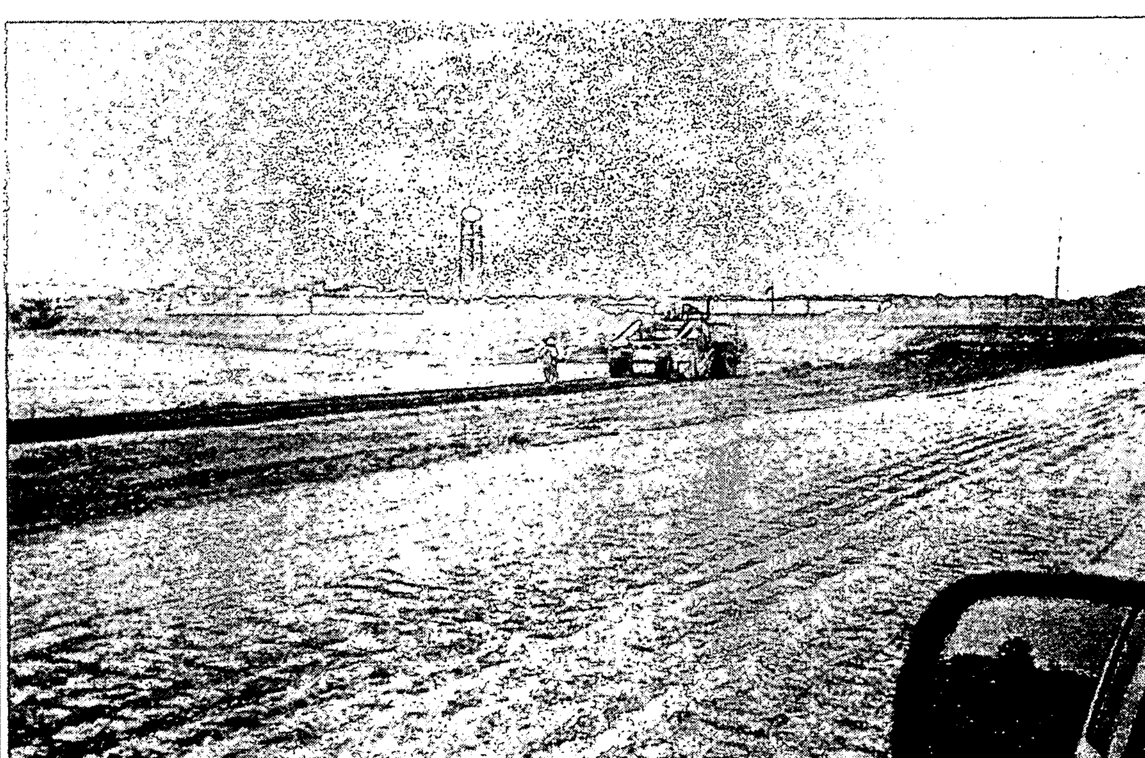

1. Soil screening operation set up in Cell 3 area.



2. Placement of clay liner material in Cell 2 using Volvo articulating dump truck and Caterpillar D-6H dozer.




3. Scarifying clay liner material with RACO 250 soil stabilizer at Cell 2 west berm.



4. Processing clay liner material with RACO 250 soil stabilizer. Laborer is removing oversized particles.

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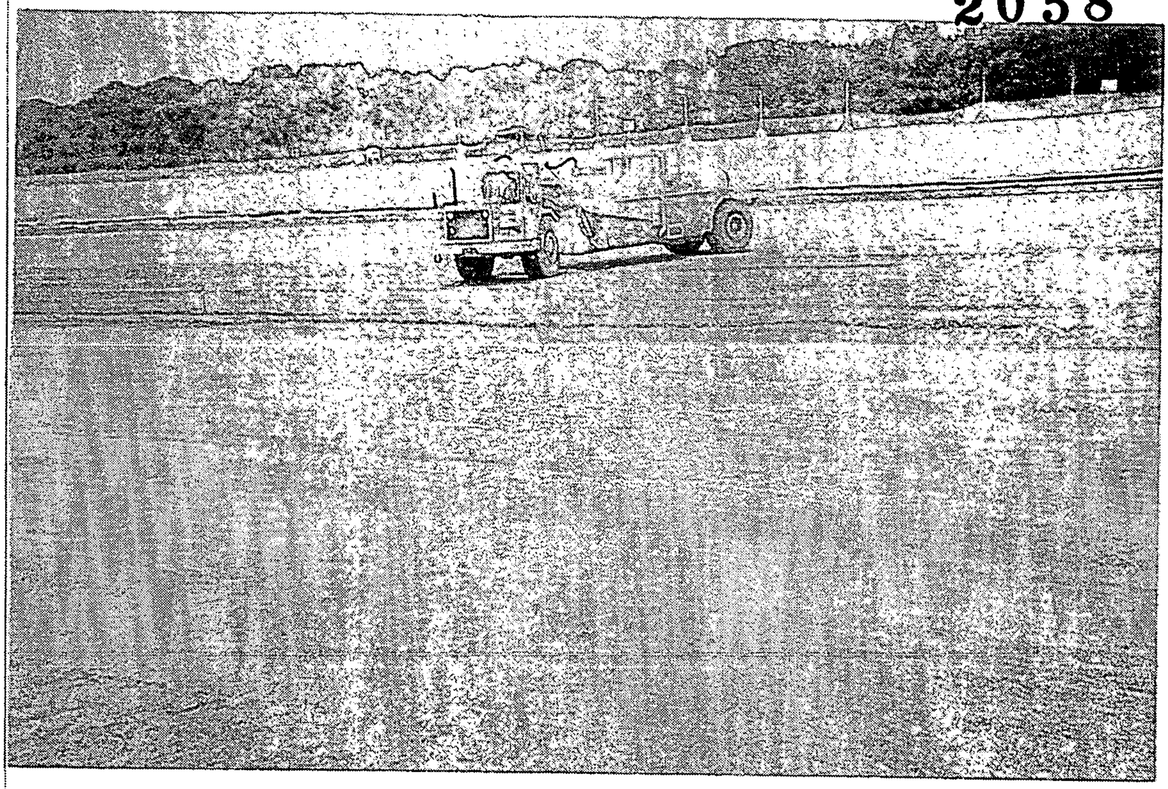
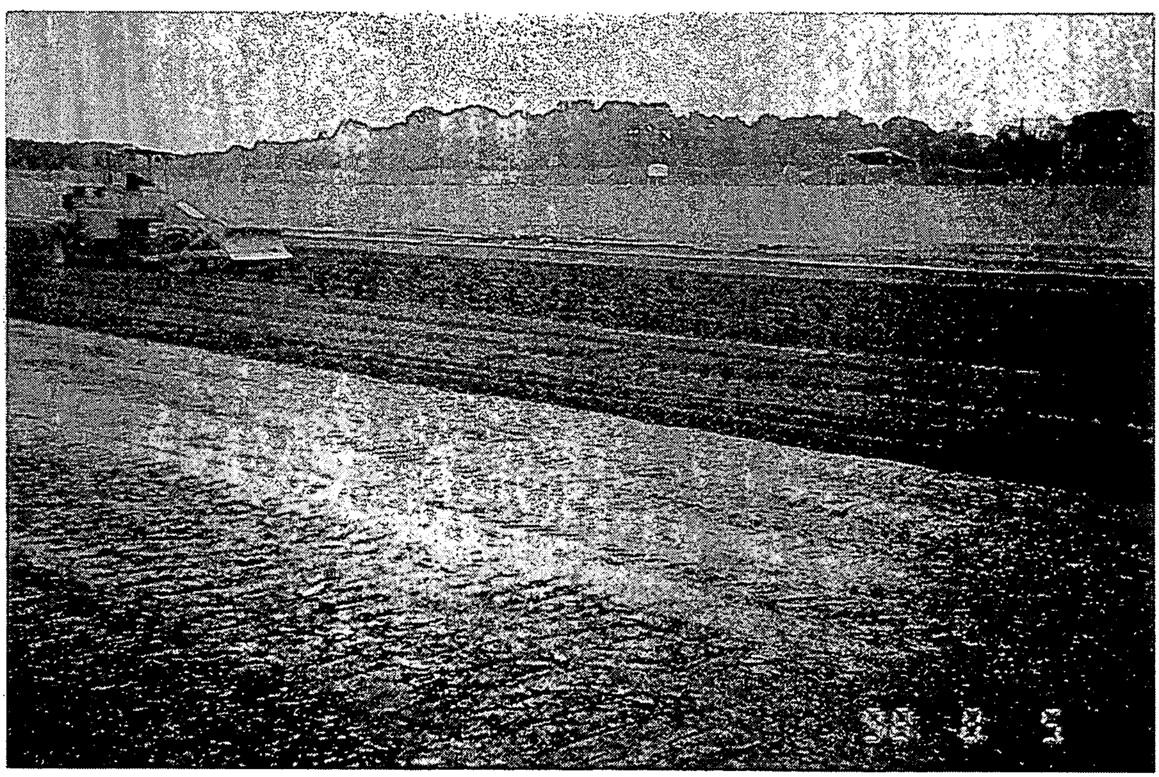


5. Moisture conditioning clay liner material prior to processing with Soil Stabilizer.



6. Caterpillar 815 soil compactor in process of compacting stabilized clay liner material.

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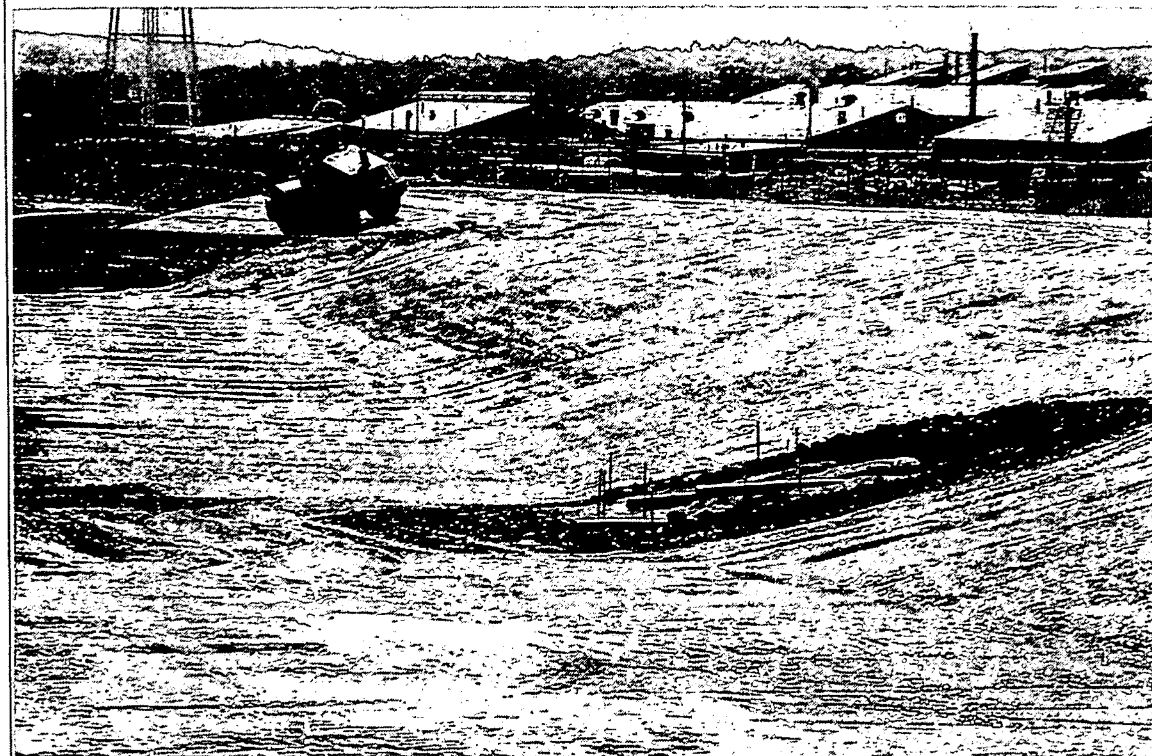
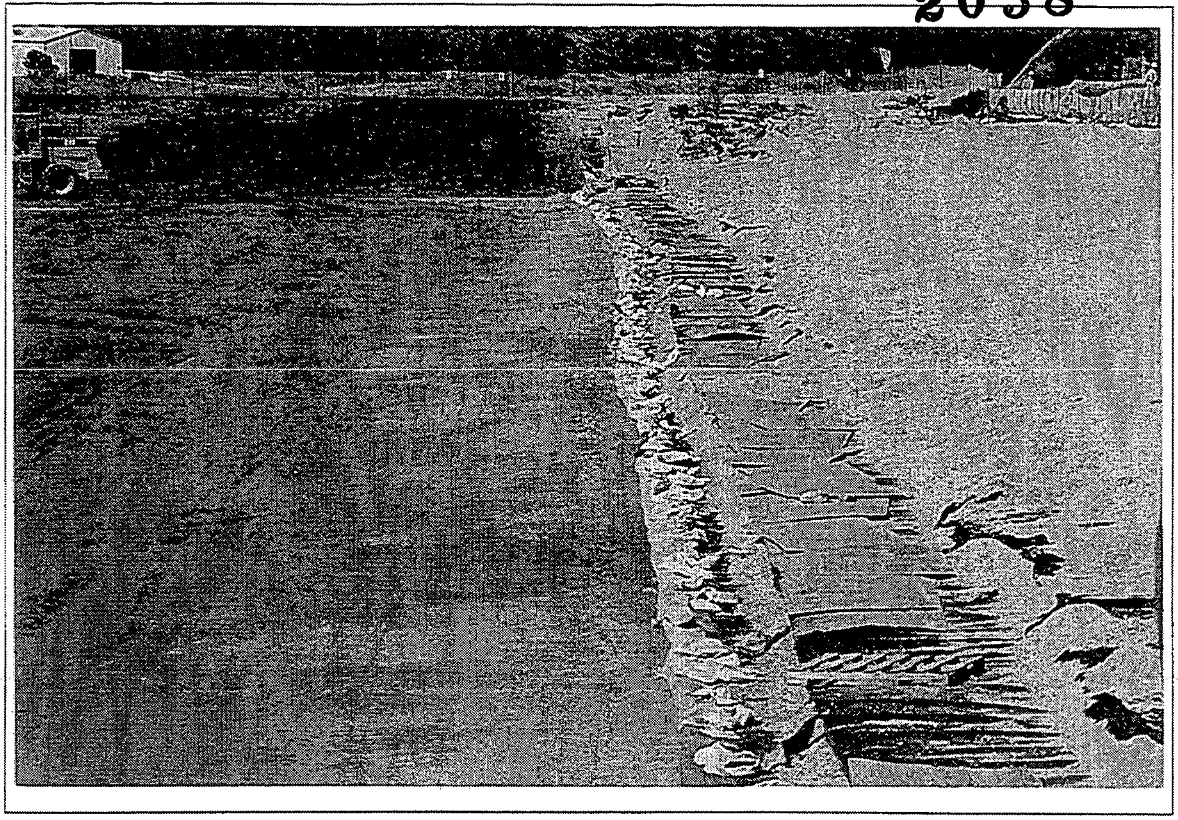
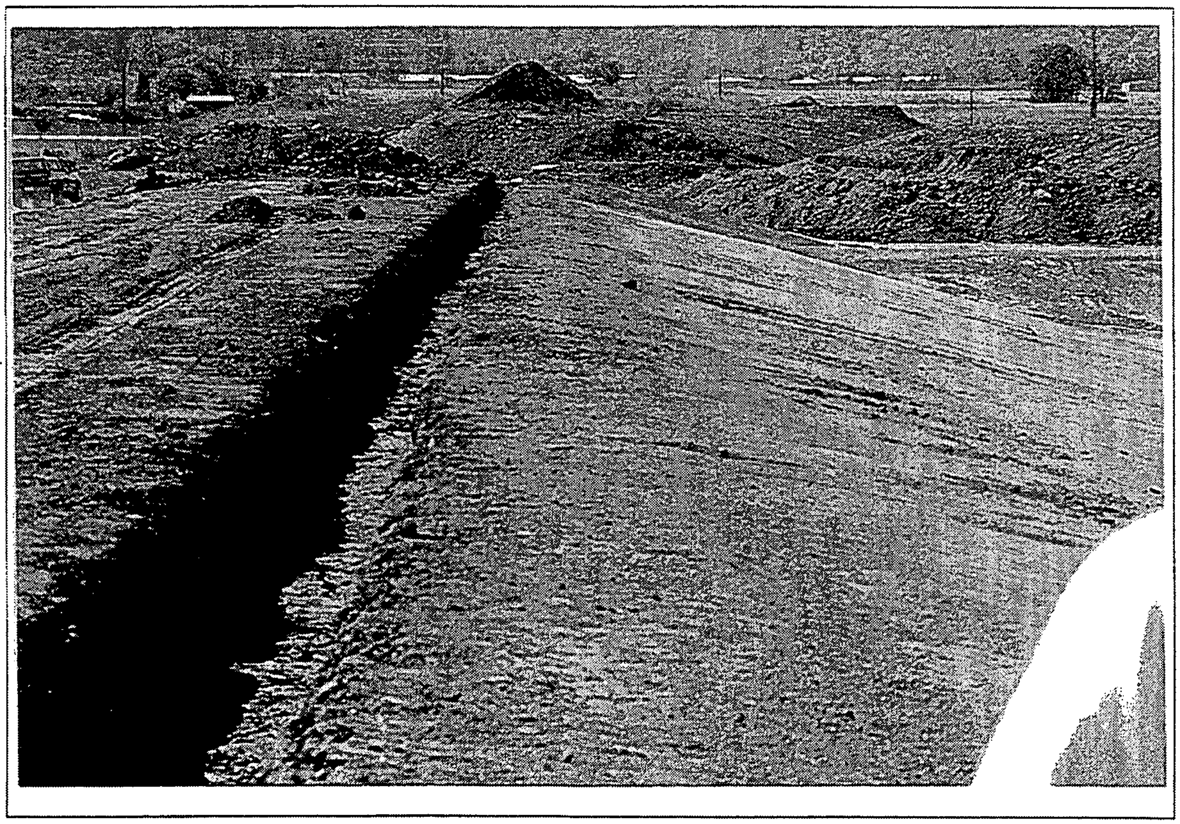


7. **Smooth Drum Roller compacting and sealing clay liner on west berm of Cell 2.**

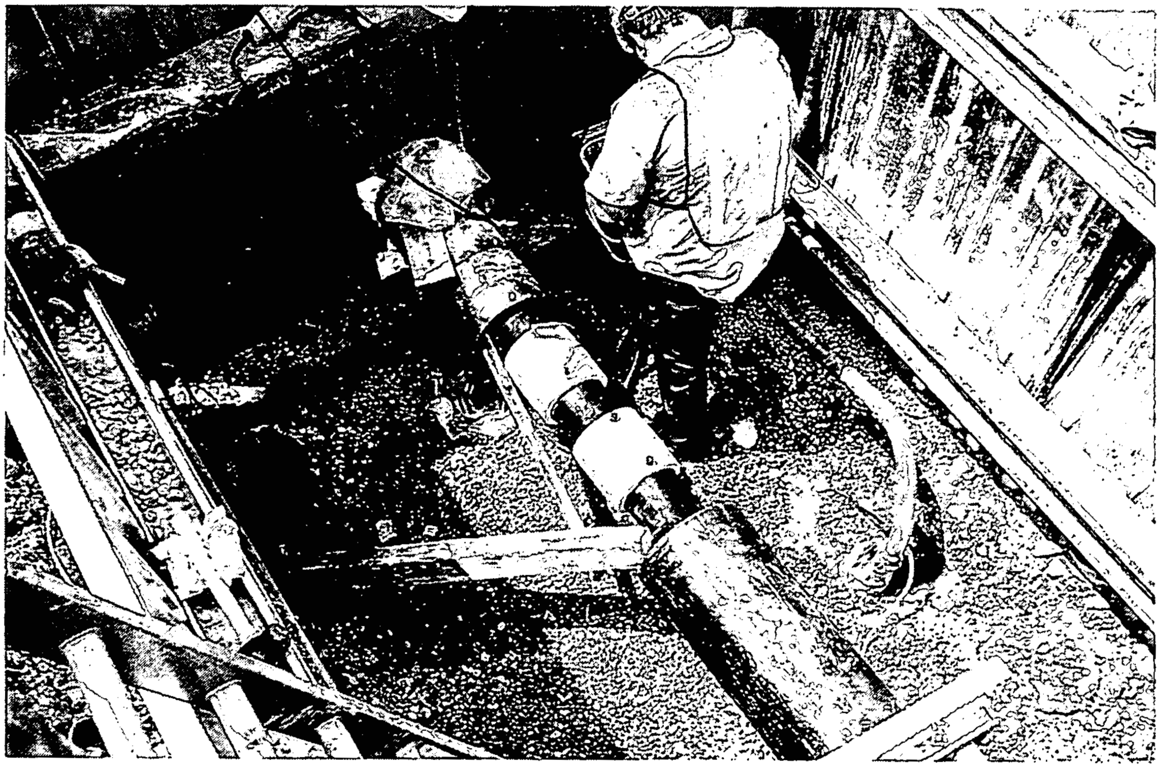
8. **Caterpillar D-6R dozer preparing clay liner material for placement on slope.**



9. Looking west at Cell 1/ Cell 2 tie-in.

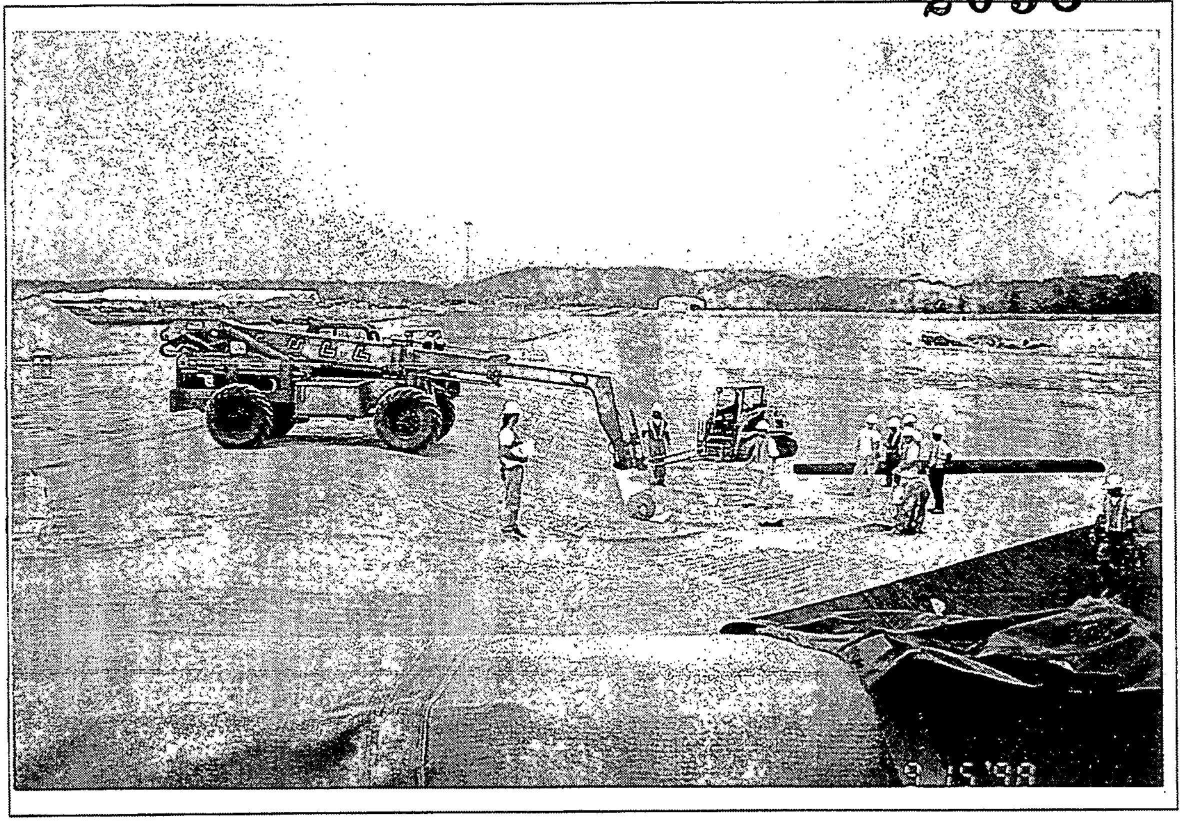


10. Secondary anchor trench at east berm of Cell 2.

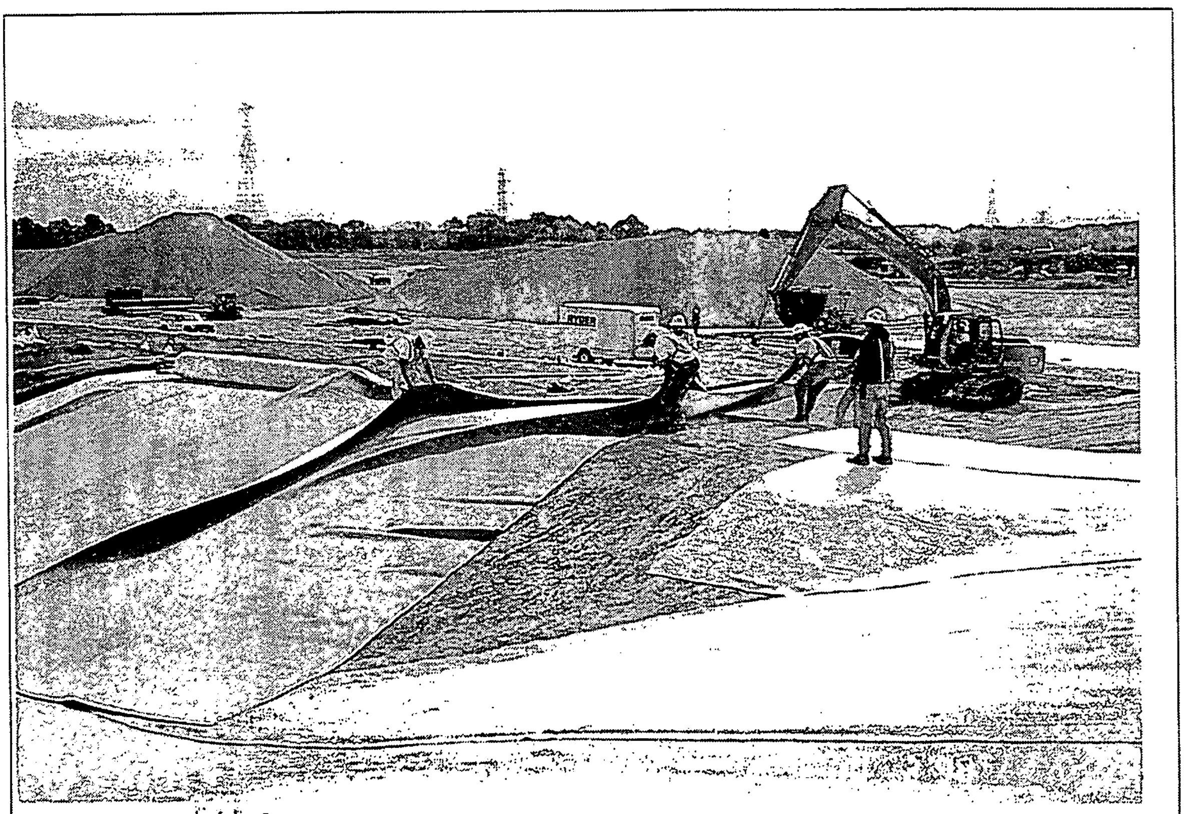


11. Electro-fusion welding the HDPE piping tie-in at the Cell 2 LCS/LDS Manhole.

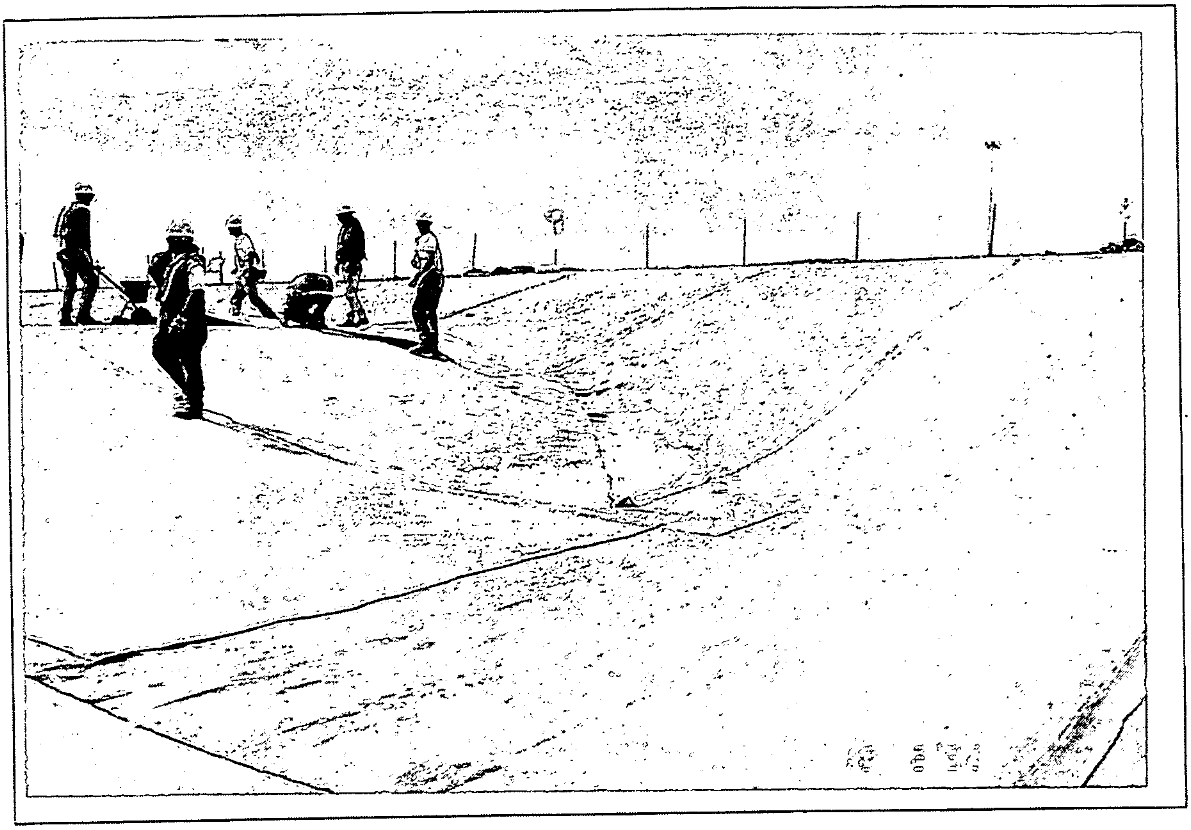
12. HDPE piping tie-in between Cell 2 and the Cell 2 LCS/ LDS Manhole.



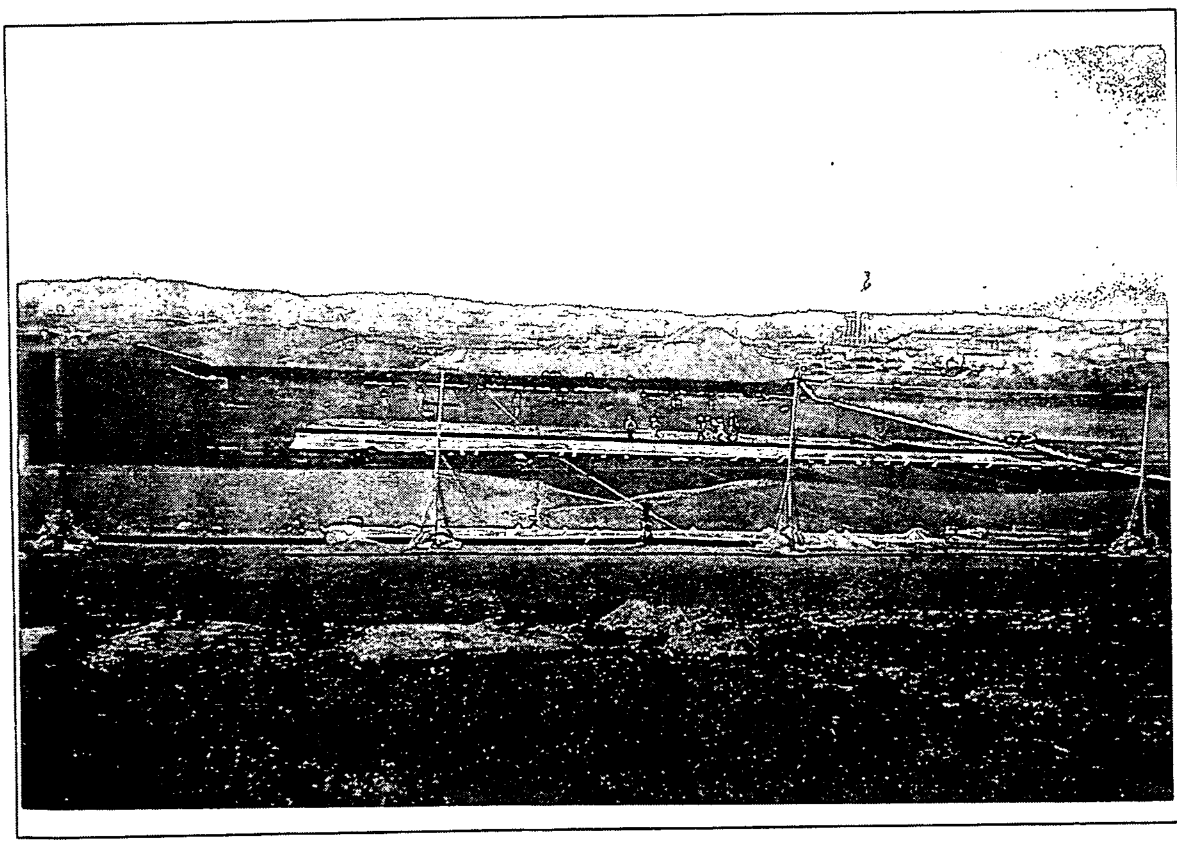
13. GCL deployment over Cell 2/ Cell 3 intercell berm, southeast corner of Cell 2.



14. GCL deployment at west end of Cell 2/ Cell 3 intercell berm.



15. GCL deployment at southwest corner of Cell 2.



16. View south from Cell 1 into Cell 2 during GCL repair work.

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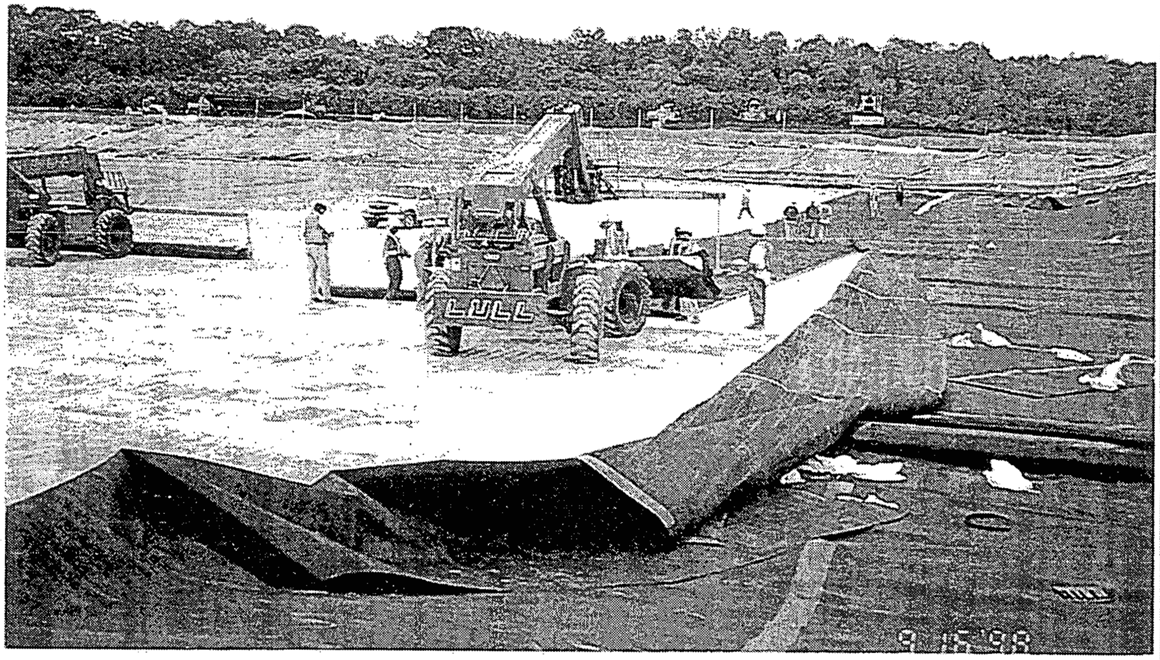
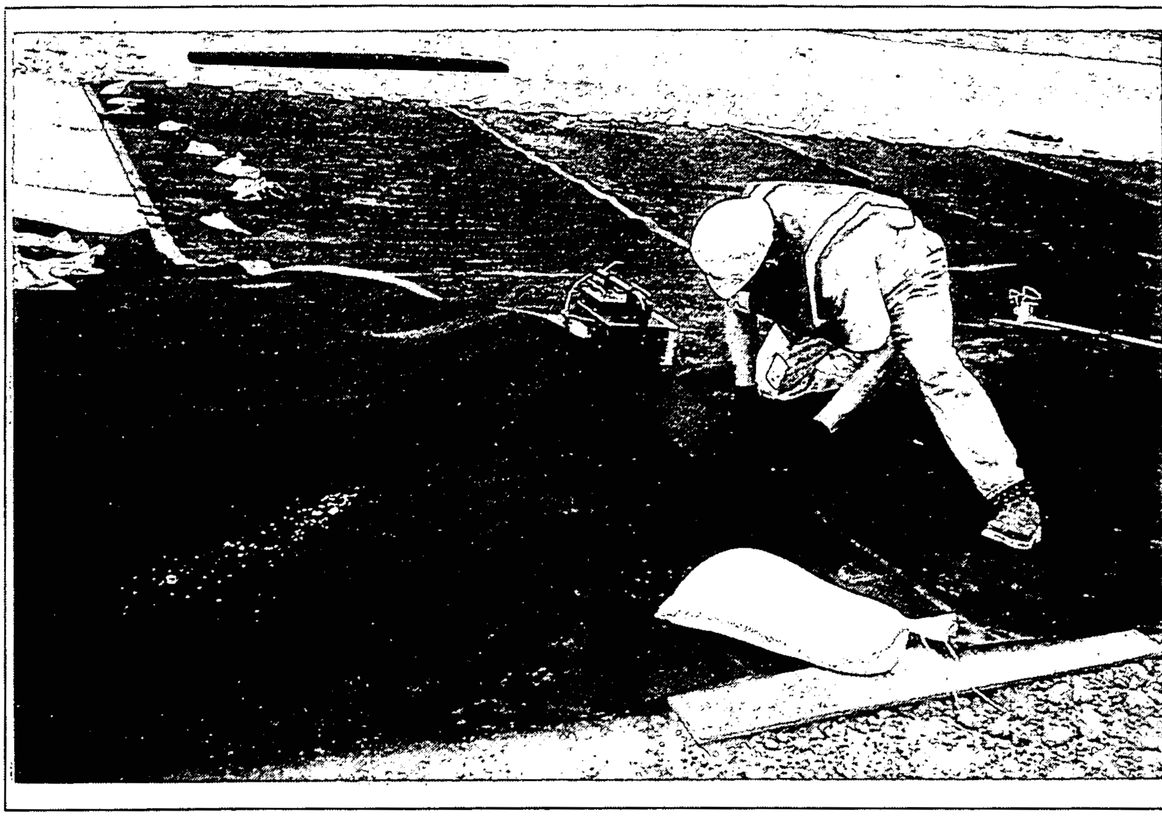


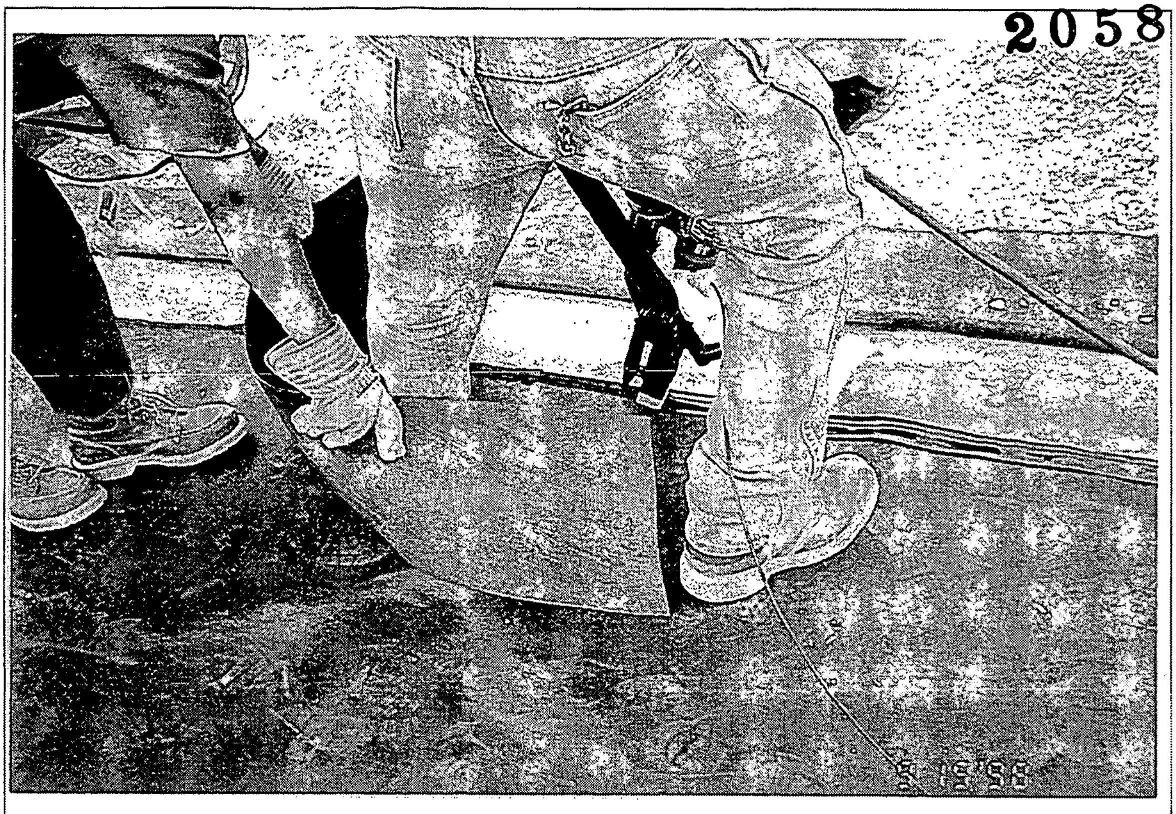

17. GCL being positioned for deployment on floor of Cell 2.

18. Double track fusion seaming of GML. GCL partially deployed over intercell berm in foregeround.

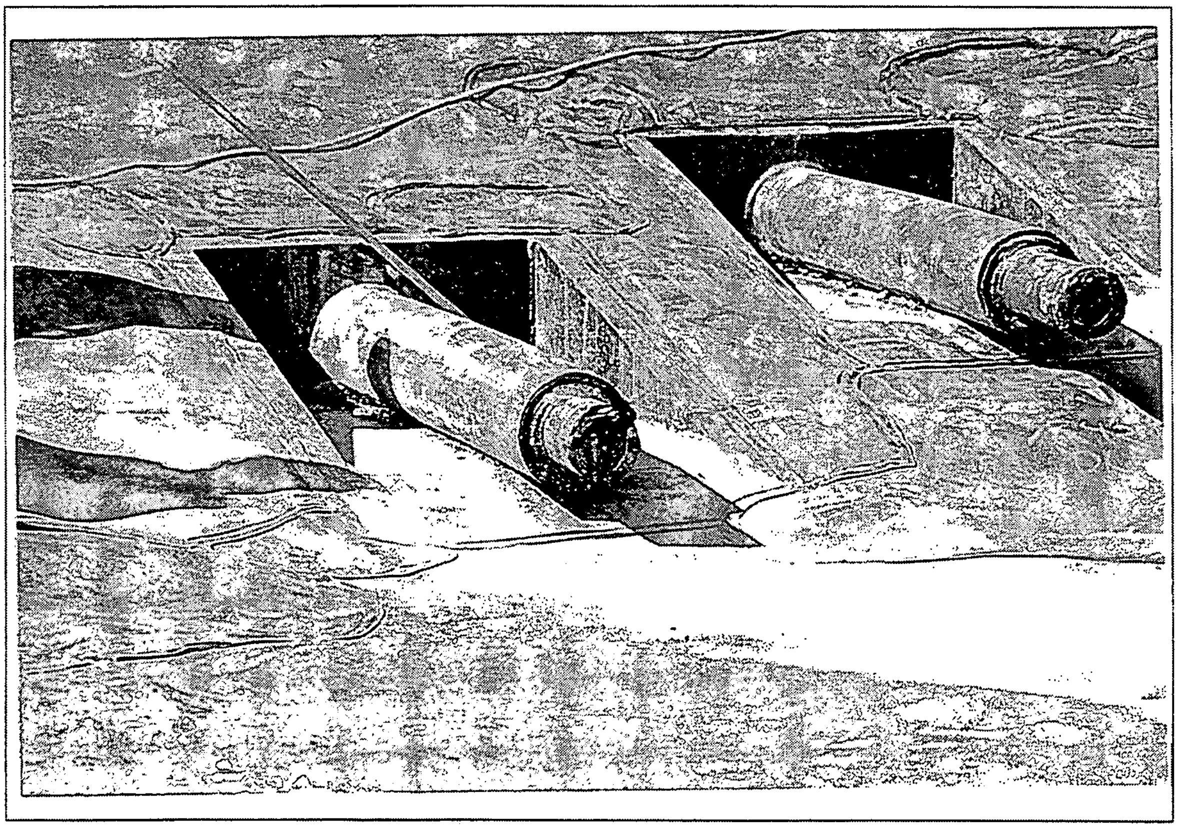


19. Seaming operator cleaning GML ahead of fusion seamer.

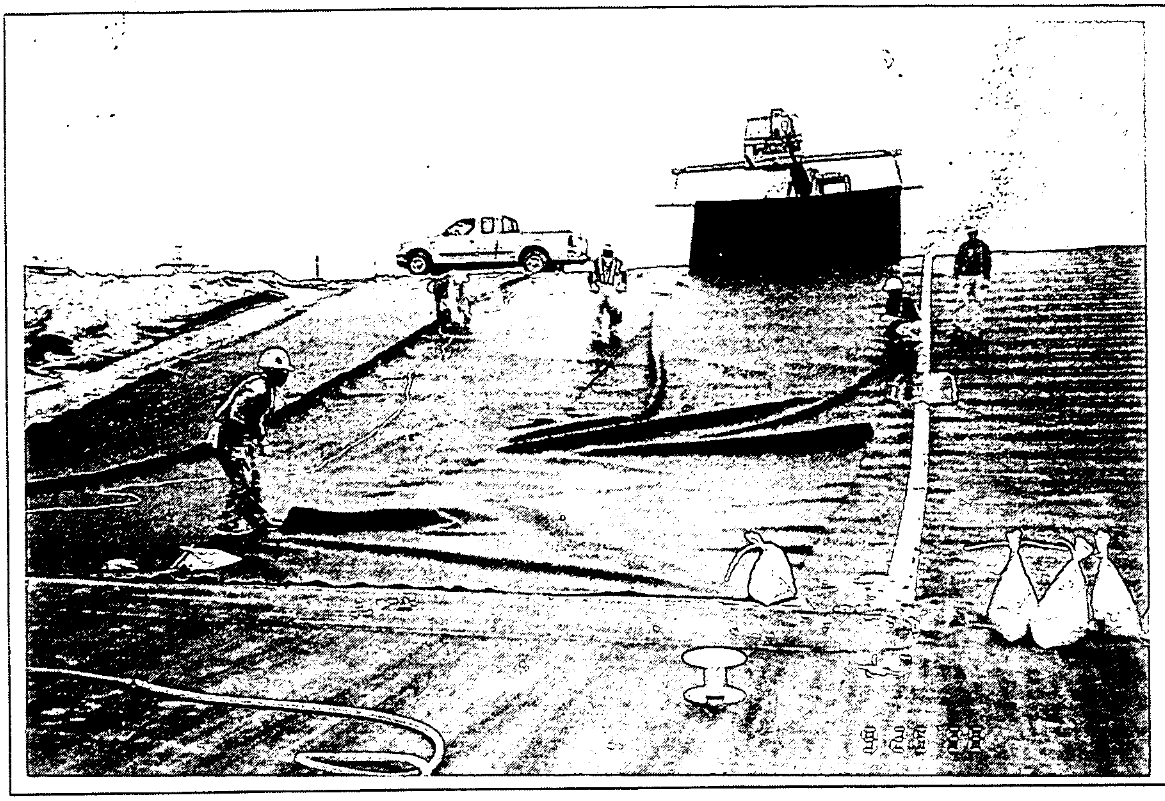
20. Quality control testing (air pressure test) of double track fusion seam.



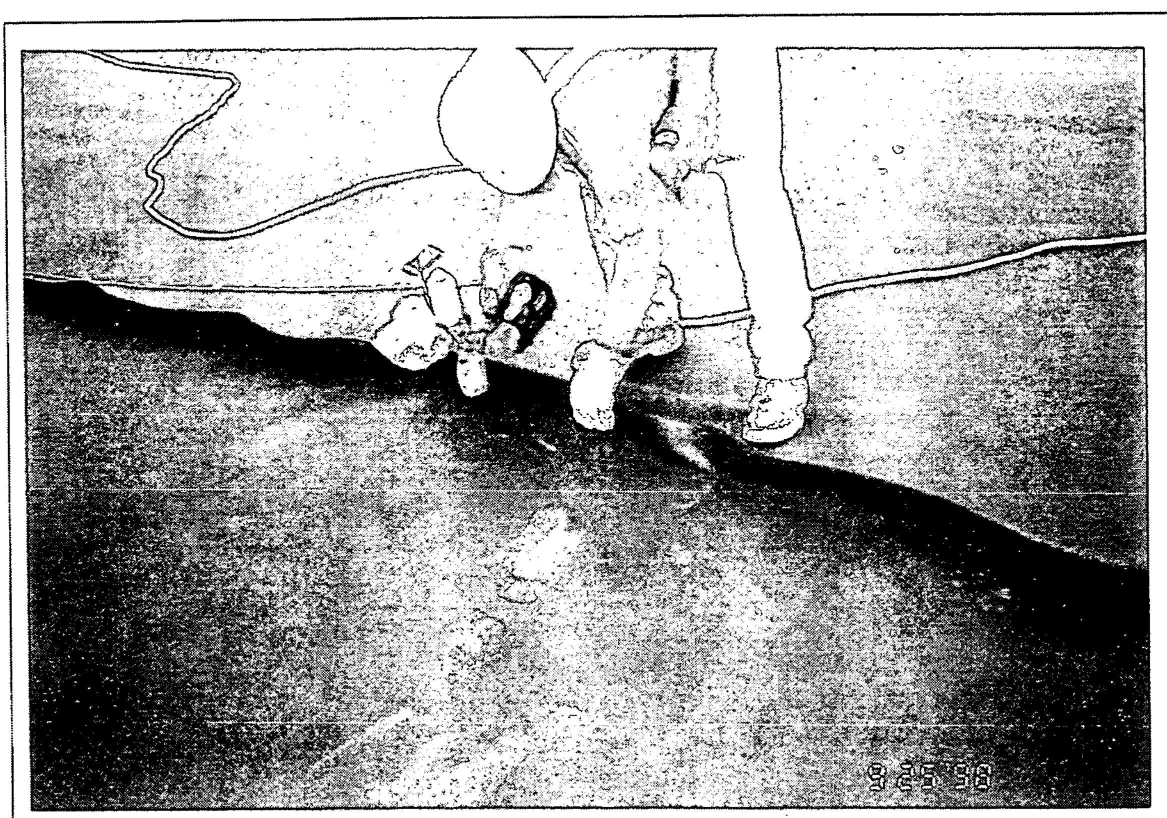
21. Extrusion welding of secondary geomembrane at Cell 1/Cell 2 tie-in.



22. Liner penetration boxes for LCS an redundant LCS piping through secondary liner system.



23. Deployment of geotextile cushion layer at the perimeter berm.




24. Sewing of secondary geotextile cushion in CELL 2.

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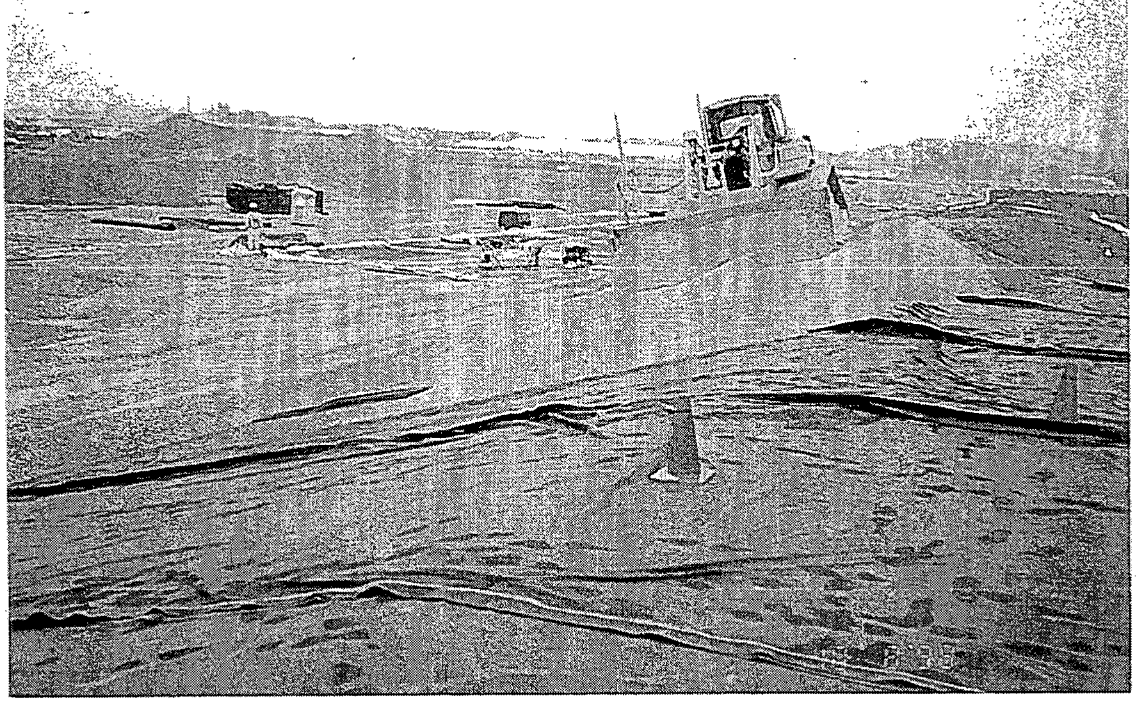
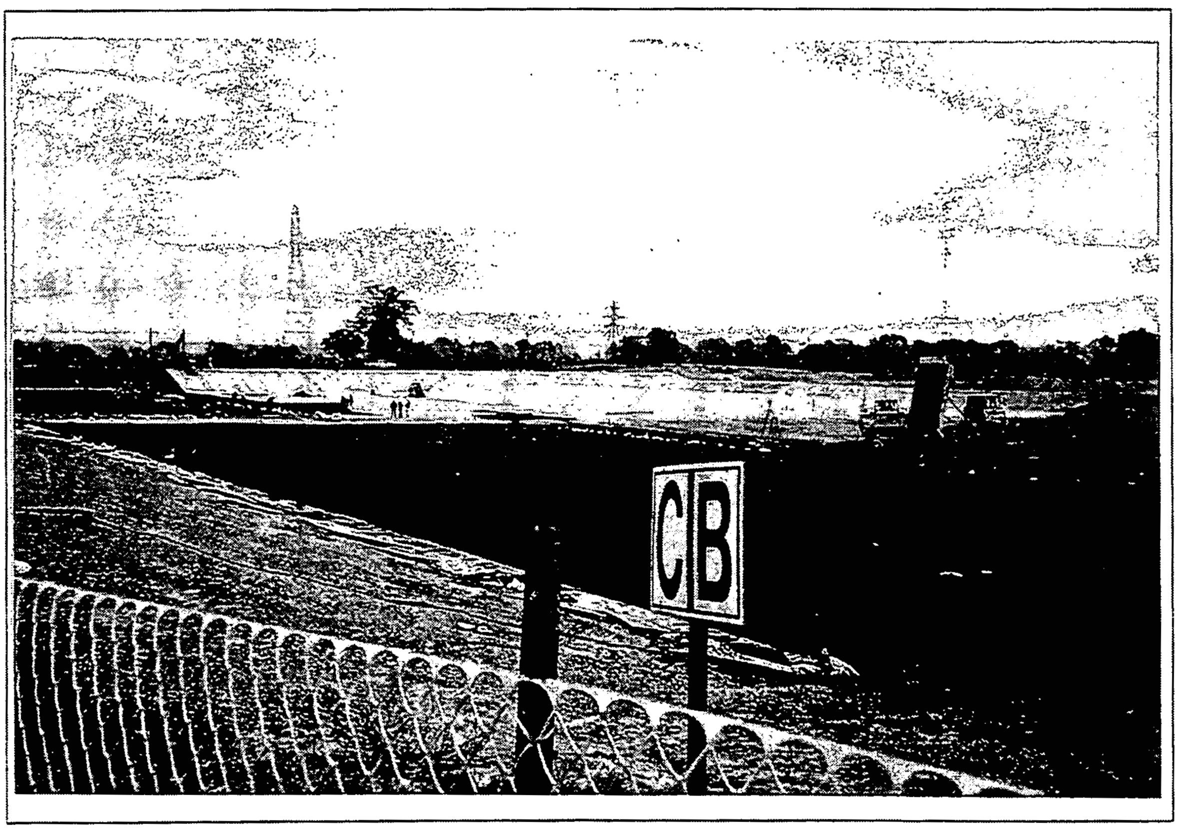


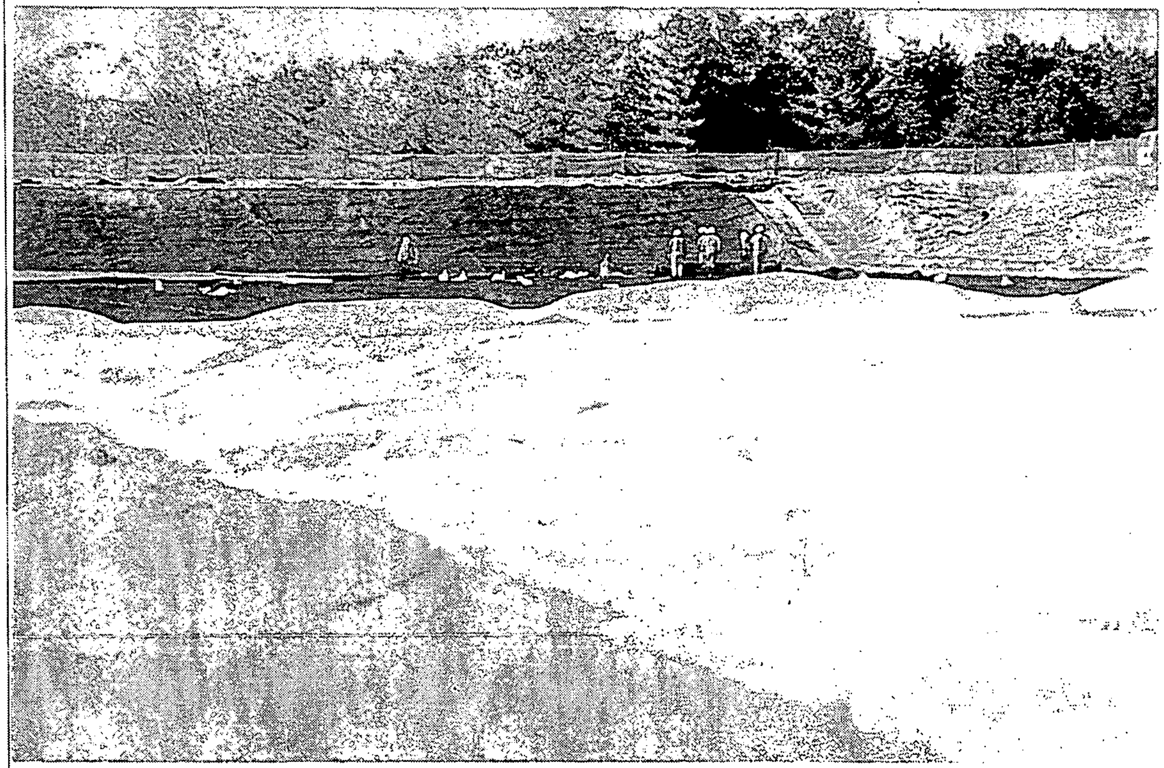
25. Number 78 stone being spread over the geotextile cushion on the Cell 2/ Cell 3 intercell berm (Cell 3 slope).

26. Caterpillar D-6R LGP dozer working on the Cell 2 clay wedge at the west berm.

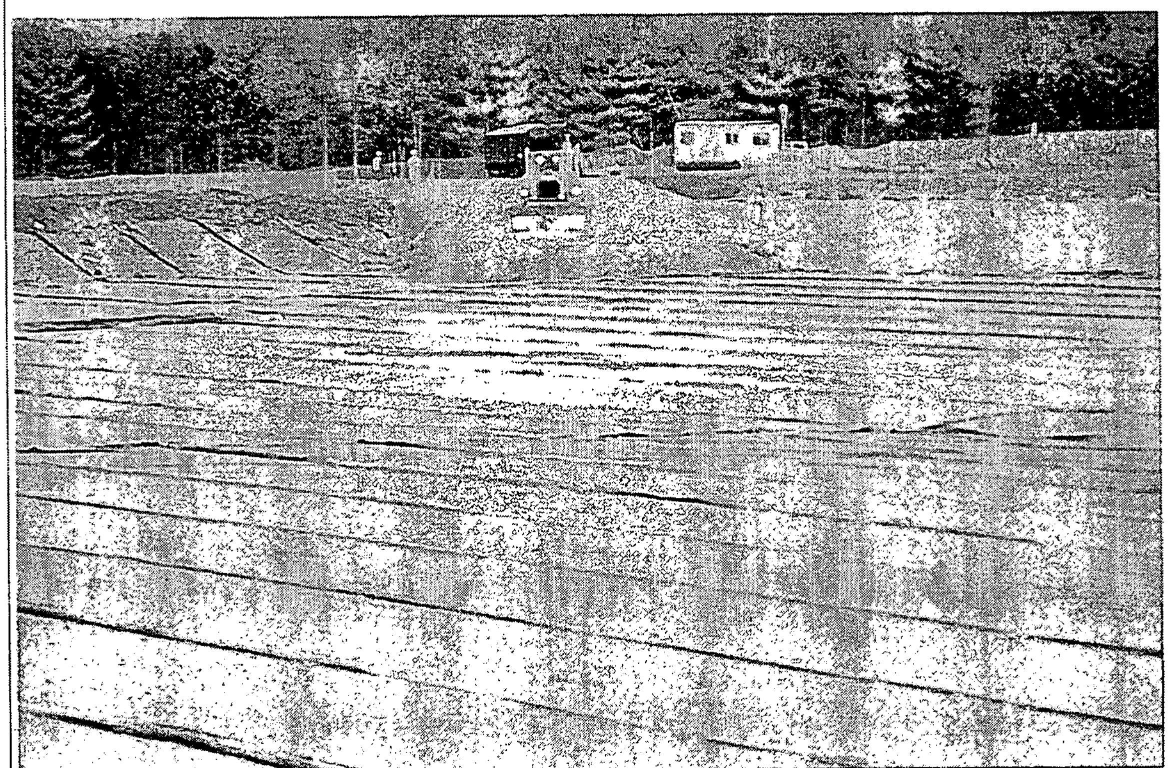
27. Liner penetration boxes for LCS and redundant LCS piping. Primary GCL deployment to right.




28. Secondary geotextile cushion being covered with stone. Primary GCL and GML being deployed over secondary stone.



29. Geotextile being deployed over primary GML, west slope.



30. Access ramp into Cell 2 over primary drainage stone.

# APPENDIX B:

# CELL 2 INTERIM CERTIFICATION LETTER

# CELL 2 INTERIM CERTIFICATION LETTER

2058

GEOSYNTEC CONSULTANTS

1100 Lake Hearn Drive • Suite 200
Atlanta, Georgia 30342-1523 • USA
Tel. (404) 705-9500 • Fax (404) 705-9400

11 November 1998

Mr. Michael J. Hickey
Fluor Daniel Fernald
MS: 64
P.O. Box 538704
Cincinnati, Ohio 45253-8704

Subject: Interim Construction Certification
On-Site Disposal Facility (OSDF) Cell 2, Phase II
Subcontract No. 95PS005028

Dear Mr. Hickey:

The purpose of this letter is to certify that the construction quality assurance and quality control (CQA and CQC) activities performed by GeoSyntec Consultants during construction of the On-Site Disposal Facility (OSDF), Cell 2 is substantially complete.

CQC personnel have monitored, tested and documented placement of soil and geosynthetic components to include cell subgrade, compacted clay liner, granular leachate collection and detection layers, geosynthetic clay liner, geomembrane liners, and geotextile cushions and filters. Field reports, logs, geotechnical and geosynthetic testing reports and other associated documentation have been reviewed for accuracy and completeness. A final certification report will be submitted in December 1998.

Based on our observations and documentation, the OSDF Cell 2 construction has been completed in accordance with the project specifications, drawings, CQA Plan and approved changes. The construction has been in full compliance with applicable or relevant and appropriate requirements (ARARs), functional requirements and general design requirements described in the Design Criteria Package developed and approved during the design process. On the basis of our observations and testing it is anticipated that Cell 2 of the OSDF will be ready to receive impacted material meeting the OSDF waste acceptance criteria (WAC) on 11 November 1998. In addition, the Leachate Conveyance System (LCS) will also be ready to handle leachate from Cell 2 as well as Cell 1.

It is anticipated that this letter will satisfy Department of Energy and Environmental Protection Agency (both US and Ohio) requirements. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

Daniel Bodine

Daniel G. Bodine, P.E.
Managing Engineer
Ohio P.E. No. E-61363

Copy to: Jay Beech, GeoSyntec
Dave Phillips, GeoSyntec

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